Vol. 2 JANUARY, 1945 No. 1

FARLOWIA

A Journal of Cryptogamic Botany

ANNIVERSARY NUMBER
COMMEMORATING
THE ONE HUNDREDTH BIRTHDAY
OF
WILLIAM GILSON FARLOW
1844–1944

PUBLISHED BY
FARLOW LIBRARY AND HERBARIUM OF HARVARD UNIVERSITY
20 Divinity Ave., Cambridge, Mass.

FARLOWIA

Published semi-annually. Four numbers compose one volume of approximately five hundred pages.

Subscription prices: Vol. 1, $5.00; Vol. 2, $7.50. Single numbers: Vol. 1, $1.50; Vol. 2, $2.25.

Subscriptions and remittances should be addressed to FARLOWIA, 20 Divinity Ave., Cambridge 38, Mass., U. S. A.

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CONTENTS OF VOL. 2, NO. 1

IN HONOR OF WILLIAM GILSON FARLOW. By *David H. Linder* 1

THE CORRESPONDENCE OF WILLIAM G. FARLOW DURING HIS STUDENT DAYS AT STRASBOURG. By *Hilda F. Harris* 11

NOTES ON FARLOW'S AGARICALES FROM CHOCORUA. By *Rolf Singer* 39

WILLIAM GILSON FARLOW: PROMOTER OF PHYCOLOGICAL RESEARCH IN AMERICA, 1844–1919. By *Wm. Randolph Taylor* 53

FARLOW'S INTEREST IN AN INTERNATIONAL ABSTRACTING JOURNAL. By *Frans Verdoorn* 71

DR. FARLOW'S INFLUENCE ON MYCOLOGY. By *William H. Weston, Jr.* 85

THE BOLETINEAE OF FLORIDA WITH NOTES ON EXTRALIMITAL SPECIES. I. STROBILOMYCETACEAE. By *Rolf Singer* 97

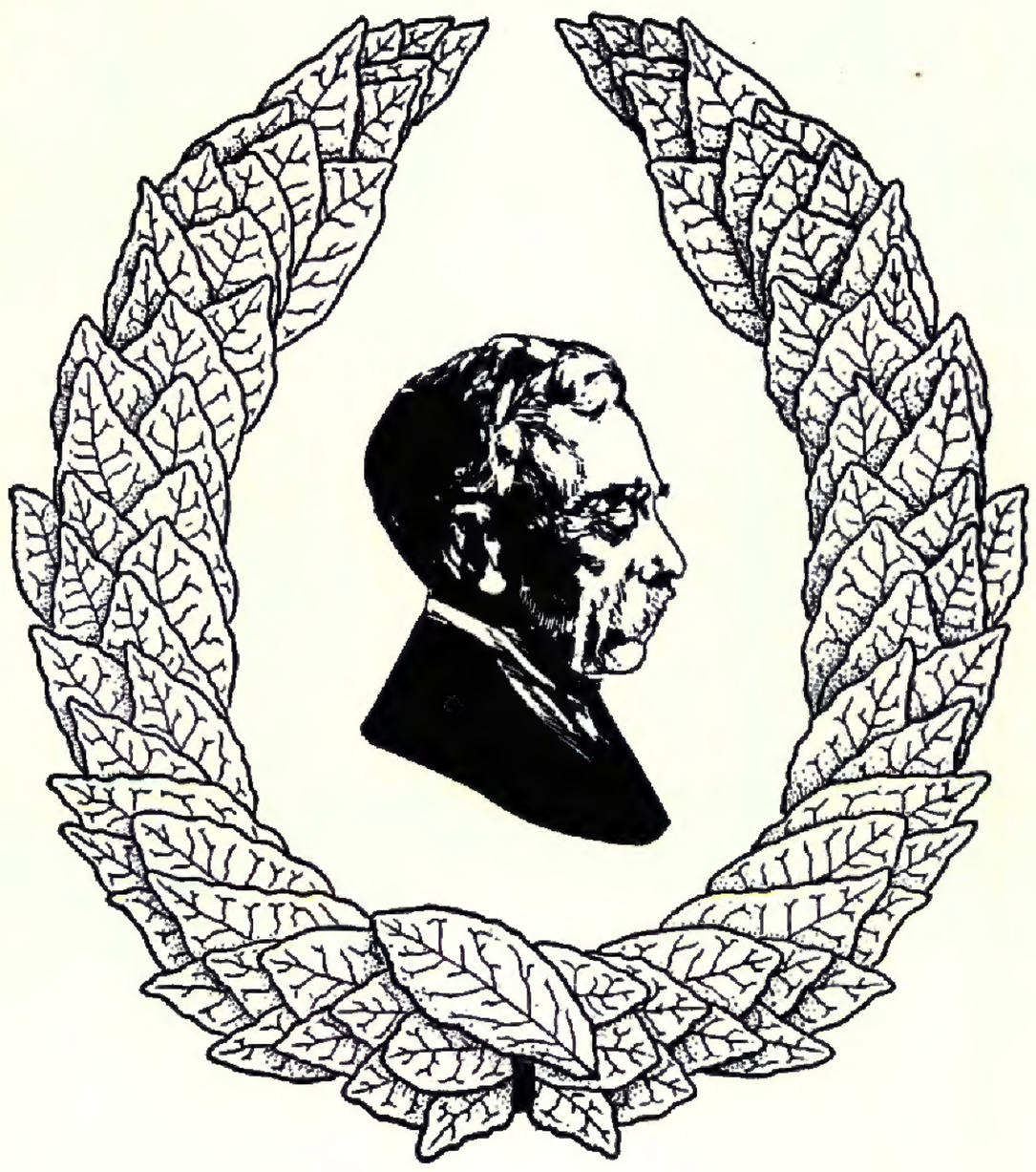
Vol. 1, No. 4, was issued on July 18, 1944.

FARLOWIA

A JOURNAL OF CRYPTOGAMIC BOTANY

VOLUME 2

1945-1946



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See page 49

FARLOWIA

A JOURNAL OF CRYPTOGAMIC BOTANY

VOL. 2 JANUARY, 1945 NO. 1

IN HONOR OF WILLIAM GILSON FARLOW

DAVID H. LINDER

Although this journal is but two years or one volume old, it is nevertheless not too young to recognize the one hundredth anniversary of the birth of the man who, through the founding of the Farlow Reference Library and Herbarium of Cryptogamic Botany, made possible its existence. The occasion is of greater importance than the mere fact of the journal's existence, for Dr. Farlow was more than a means of making its existence feasible, he was the first professor of cryptogamic botany in America and played an important part in the development of this branch of botany. Not only did he stress the importance of systematic cryptogamic botany and morphology, but he initiated in this country the teaching of what is now known as phytopathology and he also began, with Professor W. R. Nichols, the study of the rôle of algae as impurities in drinking water. His versatility and his contributions have been ably and more amply described in the biographies appended to this paper and for this reason only a brief sketch is needed on this occasion.

William Gilson Farlow was born in Boston on December 17, 1844 and there spent the first fourteen years of his life before the family moved to Newton, Massachusetts, then considerably less urban than it is today. Perhaps it was the life in the country where he was surrounded on all sides by Nature's beauties and curiosities that stimulated his enquiring mind and influenced him to become a botanist or maybe it was the influence of his father, John S. Farlow, who although a successful business man, was equally enthusiastic about horticulture, as is attested by the prizes that he won at the exhibitions of the Massachusetts Horticultural Society and by the gifts that he made to that institution. Whether it was the father's interest in plants or his own discovery of the wild *Hepatica*, which has been said to have stimulated him to pursue botany as a life study, there can be little doubt that William Farlow received the encouragement and backing of his family, and that his father by example set the pattern that he was to follow.

While at Harvard College, from which he graduated in 1866, he continued his interest in natural history, taking the courses offered by Asa Gray and being elected president of the then active Harvard Natural History

Society. On graduating from college, he spent four years at the Harvard Medical School where he obtained his M.D. degree. He did this, even though highly successful as a student, not because he was primarily interested in medicine, but because in those days botany was the hobby of amateurs who were for the most part physicians and ministers and there was little opportunity for the professional botanist. To quote his words (Science N. S. **37:** 79. 1913) "When I graduated from college in 1866 and wished to become a botanist, Professor Gray told me that I ought to study medicine first because the possibility of gaining a living by botany was so small that one should always have a regular profession to fall back upon." . . . "In 1866, there were very few botanical professorships in this country, the salaries were very small and the equipment very shabby. Gray was professor at Harvard, D. C. Eaton at Yale and Porter at Lafayette. Torrey, in spite of his distinction as a botanist, really depended on his position as a chemist for his living. The comparatively few positions in government and state stations offered few attractions and changes were frequent. To a young man the prospect was not assuring."

Upon graduating from medical school, Farlow returned to botany, becoming Asa Gray's assistant. He began in earnest to pursue his studies of cryptogamic botany but after two years, found that if he wished to progress in this field, it would be necessary for him to go to Europe. Hence, in 1872, he went abroad and spent the two following years, for the most part in the recently founded laboratories at Strasbourg under the guidance of Anton De Bary, a brilliant crytogamic botanist whose scientific conclusions were often in advance of his time and whose teaching appears to have been most provocative. But despite the fact that he was learning De Bary's methods of teaching and research, he nevertheless, on the recommendation of Dr. Gray, took out time for intensive studies of the lichens with Dr. J. Mueller and of the algae with Thuret and Bornet. The trips, if we may judge by his letters, gave him an opportunity to visit many important herbaria in different parts of Europe and to make the acquaintance of the distinguished botanists of the period, acquaintances with whom, after his return to America, he maintained an active correspondence. His stay in Europe also provided him with an opportunity to obtain rare and important volumes for his library and equally important specimens for his herbarium to which he added while still abroad, the most important Curtis collection which contained parts of the types of species described by Berkeley and other specimens obtained by exchange with Schweinitz, Ravenel, Sprague, Fries, and Duby. Thus in spite of being small in stature, a fact about which Dr. Farlow was very sensitive, he was a giant when measured by his physical and mental activity.

Although worried about the prospects of a position as a professional botanist on his return home, when he did come back to America he was appointed through the friendly efforts of Dr. Gray to an assistant professorship and five years later, in 1879, became Professor of Cryptogamic Botany. During the early days he taught not only cryptogamic botany, but

at the Bussey Institution where he was stationed the first five years, gave instruction to special students in the applied side of mycology, probably the first to be given in that now thriving field known as phytopathology, to which he was then making contributions.

When he became Professor of Cryptogamic Botany he moved from the Bussey Institute to Cambridge where he apparently enjoyed greater freedom of action and where he continued with zeal to build up his already important herbarium and library. Although still devoting his attention to mycology, he devoted more time to the algae, his first love, and published among other papers, the "Marine Algae of the New England and Adjacent Coast," a manual that has been in use up to very recent days. Although interested in the morphology and taxonomy of the algae, for which his studies well prepared him, just as with the fungi, he saw the practical importance of the freshwater algae and published three or four papers which resulted from his study of the water supply problems of the City of Boston. Again, although primarily a systematic botanist, he was one of the first in this country to demonstrate the importance of the lower forms of plant life in the welfare of the people.

Little more need be said here on Dr. Farlow's reputation as a mycologist or phycologist since these subjects are more amply discussed in accompanying papers. Less well known were his interest in lichenology and bryology, perhaps because he published little on these two subjects. However, that he did much work in these two fields is attested by a perusal of the specimens in his herbarium where can be found a considerable amount of material that had been named by him, as well as the critical notes and observations that were written in his characteristic and occasionally not too legible hand. His remarkable memory and his very broad knowledge of these groups enabled him to provide information of great value to students and specialists alike, and his herbarium was available to those who were properly qualified. At times he has been criticized for not allowing the herbarium to be used unless under supervision. This was not because of selfishness on Farlow's part but rather the result of abuse by thoughtless visitors who ruined or even entirely removed some precious specimens from his collections. Farlow did not bring together the many specimens for immediate consumption and dispersal, for his endeavors were all directed towards building a reference collection that would serve future generations of botanists who were capable of profiting by what he had done.

One cannot but be impressed by the tremendous energy shown by Dr. Farlow. Although he gave up undergraduate instruction twenty-three years before his death, he continued to take a keen interest in graduate students. In addition to his teaching, he gave considerably of his time to answer correspondence and through it to maintain the friendships that he had made as he went through life; the administrative needs took no small portion of his efforts, and withal he did a tremendous amount of research in very diverse groups of non-vascular cryptogams. Yet somehow he found time to make collecting trips inside and outside of the country, to attend

meetings of the various societies to which he belonged, and to be present at the International Botanical Congresses. It is small wonder that he had little time for publishing the results of his own observations. In addition to the activities indicated above, he was also interested in founding an international journal in which could be found the names of new species of plants that had appeared in the scattered literature during the short intervals between issues, thus serving to lighten the bibliographic tasks of the systematists and applied botanists as well. As papers were being published at an increasing rate in widely scattered journals, it was even at that time a problem to keep abreast of the current literature and only by personally supporting an assistant and bibliographer was he able to maintain an index of his own covering the fungi that had been described from North America. This index, in 1919, contained some 300,000 entries and was available to colleagues for consultation. The reason behind all these efforts seems best to be explained by his own words (Science N. S. **37:** 7. 1913): "I, who was almost the first American student to seek the benefit of botanical instruction abroad, have lived to see the time when a very large number of botanists have brought back to America the best that Europe has to offer. There was a time when our botany might have been said to bear the mark 'made in England.' In more recent years it may be said to have been 'made in Germany.' There are some patriotic souls who hope the time will come, if it has not already come, when we may say 'made in America.' I do not share their feeling. To me it seems that botany is destined to become world-wide and it will be enough if we can contribute our proper share to the general stock." Dr. Farlow died in 1919 before the intense nationalism that grew up in the following years exploded into the chaos of our time. Let us hope that when the present conflagration is over, humanity may have learned the need of not only the scientific but also the political coöperation that he hoped to see.

While still a student in Europe, Farlow realized the dangers of the mad rush to every new fad that comes up in each generation to the neglect of systematic botany, for he wrote to Gray "I have been to see Prof. Pfitzer, who is a pupil of Hanstein, the man who doesn't think it any consequence to study the forms of common plants, but much better to mope over the 'Vegetationspunkt.' Dr. Hillebrand and I agree that, at the rate the Germans are going on, in twenty years there won't be a botanist in Germany who knows anything about the flora of the country." In many respects his prophecies were fulfilled, though at a slightly later date. At all events, he was sufficiently convinced of the importance of systematic botany to bend all his energies and a goodly portion of his means towards building up the library and herbarium to make possible the continuance of this line of study. He bought books, new and old, as they appeared on the market; he bought exsiccati sets and had one of the best collections of these in the country; he collected specimens during his trips at home and abroad and determined many specimens for his colleagues and thus gathered an herbarium that was very representative of nearly all groups of cryptogamic

plants. All of this he gave to Harvard University along with an endowment which, although not sufficient to maintain an adequate staff was, until the recent depression, enough to carry on in a very modest way the work that he had started.

Just as Dr. Farlow was a systematist who saw the importance of other biological fields and, indeed, helped to initiate them, his successor, Dr. Roland Thaxter was of much the same stamp and likewise continued to stress the importance of systematic botany when all young mycologists were stampeding into the rapidly growing field of phytopathology. A former student and later a very close friend of Dr. Farlow, Roland Thaxter continued his predecessors's policies, buying the important mycological herbaria of von Hoehnel, Patouillard, Burt, and Bucholtz, the lichenological herbaria of G. K. Merrill and of Sbarbaro, and the bryological collection of Fleischer and parts of the Stephani herbarium. To these have since been added the Sprague and Bartholomew herbaria of fungi and the Verdoorn herbarium of Hepaticae. These herbaria in addition to the Curtis collection of fungi, the James, Austin, and Sullivant collections of bryophytes, and the lichenological herbarium of Tuckerman, are rich in type specimens and accordingly very important to the systematist. As a result of the accretions over the years, the Farlow Herbarium is one of the largest, if not the largest, of its kind in America and rivals the few large ones in Europe. Today the library contains some 36,000 volumes, including periodicals, pamphlets, and reprints, most of which deal with the field of cryptogamic botany. It contains many rare and indispensable books of which some are not represented elsewhere in this country. The herbarium, with its many types or classical species, today contains 969,610 specimens distributed in the various groups as follows: fungi 529,885, lichens 119,315, algae 54,582, mosses 222,579, and hepatics 43,249. Thus the Farlow Reference Library and Herbarium of Cryptogamic Botany in collaboration with the Laboratories of Cryptogamic Botany, which have become separated and are now located in the Biological Laboratories building nearby, is in an excellent position to continue the tradition established by Farlow.

Since Dr. Farlow placed so much emphasis on systematic botany and showed his faith in the importance of the subject by devoting the greater part of his life and means to building up the institution that bears his family's name, it seems desirable to examine the standing of this phase of botanical science as it is at present. There is little doubt that with the opportunities opened up by plant and forest pathology, and to a lesser extent medical mycology, systematic mycology has been neglected, much to the detriment of both mycology and those related fields. The war has brought to light additional fields in the study of antibiotics (with penicillin as a shining example) and of deterioration of manufactured materials which, although a less spectacular field of investigation, is nevertheless important because it increases the cost of the war and thus effects every American through that sensitive organ known as the pocketbook. There is little doubt that these two new lines of endeavor — they cannot be called

fads since they are of tremendous immediate importance — are for some time going to drain young men from mycology, and that systematic studies, in the eyes of the public and even of scientists themselves, for they are not beyond the reproach of being shortsighted when it comes to recognizing a subject outside of their special fields, will fall into oblivion and accordingly will lose the meagre support that they now receive. We have seen how German botany, once virile, almost perished without systematic botanists.

How would the related fields of botany, or of chemistry or any other branch of science that deals with living organisms suffer? We have already seen in this war that when a person not properly trained is assigned to a primarily botanical task, it is not until the botanist with systematic training and with the accompanying techniques is called in that the essentially botanical problem begins to clarify and to yield results or to clear up inconsistencies that have previously been baffling.[1] Just as it is nearly impossible for a chemist to step in and solve a mycological problem (and vice versa) most effectively, so too is it when a chemist, a doctor, a physiologist or what-have-you tries to do monographic work or determine unusual forms of plant life. To do this needs the experience that the taxonomist has received through training and, even more important, through the experience of constantly studying a wide range of material and the necessary literature. The classification of organisms is but one phase of systematic work. Another phase is the collecting of material. Taxonomists are looked upon much in the same light as the pack rats, — never satisfied with what they have. This is rather praise than criticism, for it is only by gathering extensive lots of material from various localities and under different ecological conditions that it is possible to determine the range of variation of a species. Furthermore, it has been from the kleptomaniac instinct that our knowledge of the organisms that inhabit this green globe has increased, not infrequently to the great benefit in a practical way to the economics of a people, as is shown by the development of disease resistant strains of wheat. Whatever of an experimental nature is performed, it is fairly certain that the experiment cannot be repeated or of general value unless the organism has been accurately described and properly named.

Much more could be written concerning the importance of systematic botany and of the necessity of libraries and herbaria, to say nothing of financial support, for its proper and continued development. However, it is hoped that the present remarks are sufficient to emphasize that while immediate practical or economic application of knowledge is of great importance, nevertheless it is impossible to tell when the so-called useless knowledge of pure science may be called upon. It is therefore desirable that there be a balance of a sort between applied and pure science. This seems to be one of the lessons that we can learn from Dr. Farlow's life.

HARVARD UNIVERSITY
CAMBRIDGE, MASS.

[1] Emmons, C. W. — Misuse of the name "Trichophyton rosaceum" for a saprophytic Fusarium. Jour. Bact. **47**: 107–108. 1944.

A LIST OF NOTICES AND BIOGRAPHIES

Blakeslee, A. F., R. Thaxter & W. Trelease. William Gilson Farlow. Amer. Jour. Bot. **7:** 173–181. 1920. With portrait and bibliography.

Clinton, G. P. William Gilson Farlow. Phytopath. **10:** 1–8. 1920. With portrait.

Jackson, C. L. William Gilson Farlow. Proc. Amer. Acad. Arts & Sci. **57** (18): 484–491. 1922.

Mangin, L. Notice sur M. William Gilson Farlow. Comptes Rend. Acad. Sci. (Paris) **169** (11): 445–448. 1919.

Riddle, L. W. William Gilson Farlow. Rhodora **21:** 1–8. 1920. With portrait.

Robinson, B. L. *in* S. E. Morison. The Development of Harvard University since the inauguration of President Eliot. Chapter XXII Botany, 1869–1929. pp. 366–370. 1930.

S. H. V. William Gilson Farlow. Ann. Bot. **33** (132): XV–XVI. 1919.

Setchell, W. A. William Gilson Farlow, 1844–1919. Nat. Acad. Sci. Mem. **21:** 1–22. 1927. With portrait and bibliography.

Thaxter, R. William Gilson Farlow. Harvard Graduates Magazine. pp. 269–277. 1919. With portrait.

———. William Gilson Farlow. Bot. Gaz. **69** (1): 83–86. 1920. With portrait.

———. William Gilson Farlow. Amer. Jour. Sci. **49** (290): 87–95. 1920. With portrait.

———. The Farlow Library and Herbarium of Cryptogamic Botany. Harvard Alumni Bull. **29** (24): 679–686. Illus. 1927.

———, **W. J. V. Osterhout & T. W. Richards.** Minutes on the life and services of Prof. William G. Farlow. Harvard Univ. Gaz. **15:** 60. 1919.

W[akefield], E. M. William Gilson Farlow. Kew Bull. Misc. Inf. **1919** (9); 388–390. 1919.

THE CORRESPONDENCE OF WILLIAM G. FARLOW DURING HIS STUDENT DAYS AT STRASBOURG

Hilda F. Harris

Dear Dear Father

Thanks for your photo.
Very nice! Love your moustache
suits you well!

PLATE I

2(1): 9–37 FARLOWIA January, 1945

THE CORRESPONDENCE OF WILLIAM G. FARLOW DURING HIS STUDENT DAYS AT STRASBOURG

HILDA F. HARRIS

In June, 1872, Asa Gray wrote to his friend Alphonse De Candolle in Geneva, "My youthful assistant of the past two years goes in a week or two to Europe, to study in some German university for a year or two; to Strasburg, I think, unless he first should go to Sweden, and there study Algae, with Agardh, if he will receive him. He takes a fancy to lower Cryptogamia. His name is Farlow, an honest, good fellow. He will most likely be in Switzerland in the summer; and I shall give him a letter of introduction to you, whom he will wish to know. But take no trouble on his account, except to introduce him to Dr. Müller, from whom, as a working lichenologist, he could learn much." [1]

With this modest introduction, William Gilson Farlow set out to indulge his "fancy for Cryptogamia" in two profitable years of study and travel in the outstanding botanical centers of Europe. Farlow's interest was well placed, and received the whole-hearted approval of Gray, who was quick to recognize the abilities of his young assistant, and was eager to have him return home equipped to introduce the study of the lower plants into the Harvard curriculum. The story of Farlow's study in the laboratory of Anton De Bary is chronicled in an exchange of letters between the two men — long letters from Farlow, rich in newsy narratives of the activities at Strasbourg, and briefer ones from Gray, revealing his deep interest in Farlow's progress and generous with wise advice as to the most profitable plan of study. By direct quotation from these letters [2] it is possible to create a picture of this interesting period in Farlow's life in which he received the preparation which was to influence so strongly his botanical

[1] Letters of Asa Gray edited by Jane Loring Gray. **2:** 625. Houghton Mifflin. Boston. 1893.

[2] The letters from Gray and De Bary may be found in the Farlow Library; those from Farlow have been generously lent by the Gray Herbarium, and the writer wishes to express her thanks to the Director, Prof. Merritt L. Fernald, for permission to quote from them. The two Christmas letters from Strasbourg have been added recently to the collection at the Farlow Library by Dr. David H. Linder, whom the writer wishes also to thank for suggestions made during the preparation of the manuscript. Dr. Rolf Singer has very kindly contributed the translation of De Bary's letter from the German. In a few of the letters quoted, obvious errors in grammar or spelling have been corrected.

PLATE I. A portrait of W. G. Farlow, sent home during his European trip. Gray acknowledged its receipt in his letter of March 23, 1873, of which the portion is here reproduced in which he characteristically remarked, "Thanks for your photo. Very nice! How your moustache sets you off!"

work in this country, and during which time he acquired the nucleus of his now famous herbarium and library.

Farlow's first months in Europe were spent in traveling, but even then he was anticipating the prospect of his winter's work, for he wrote on August 12:

> Everyone speaks in glowing terms of De Bary and I hope to be suited with Strasburg. Hofmeister has gone to Tübingen and it will not be far to go to see him if it seems best . . . I am anxious to get to studying. I enjoy roaming about very well but I like better to be settled.

It was not until October 6 that he wrote that he was in Strasbourg at last, and had met De Bary. "His appearance is not striking. He is small and homely and looks too young to have written as much as he has."

If this initial meeting with De Bary failed to come up to his expectations, Farlow's impressions of Strasbourg were even more disappointing. Strasbourg had surrendered to the Germans in 1870 during the Franco-German war, and Farlow arrived there two years later to find the city still filled with soldiers, the university enrollment shrunk to a mere 250 students, and the German language, which he had hoped to master thoroughly during the course of his studies, spoken poorly and with an "Alsatian twang." Farlow took an immediate and permanent dislike to the city itself. In his letter of October 6 he complained:

> I do not, now, think I shall be able to endure Strasburg longer than one term. It is one of the most disagreeable places I have ever been in. The weather has been horrible. I have been here, in all, ten days and not a single one at all pleasant and the weather cold and raw. I cannot keep warm. As for society, there is absolutely none. The university instead of having 1500 students has only 250 and no English or Americans . . . Prof. De Bary thinks Strasburg will be a very good place to learn German but I do not agree with him. The people don't speak German and there is no society here except military men with whom I am not likely to become acquainted. I am almost sorry that I didn't go to some northern city and study the language and let botany alone for some months.

As time passed, only a growing realization of the excellence of De Bary's instruction forced him to admit reluctantly to himself that he could not hope to receive such training in any other place. As he said later (April 23, 1873) after a visit to Heidelberg:

> [It] is certainly one of the loveliest places I ever saw and is particularly beautiful in spring when all the trees are in flower. I was glad to come here because I wanted to find out, for myself, whether it is really a good place to study or not . . . Accordingly Veni, Vidi, but *not* Vici. I find that H. is not to be compared with Strasburg for botany and I leave tomorrow for the latter city to stay during May and June with De Bary.

Farlow has described conditions as he found them at the University of Strasbourg in a short paper which he wrote in October, 1873, intending it

for publication in the series of articles which appeared in the American Naturalist. In it he said:

> The University of Strassburg which has, for two years, been under the control of the Germans, stands, as far as botany is concerned, in the first rank. It is rather the fashion to say that the University has been created by the Germans. This, however, is not true, unless we adopt the view that nothing can be a University which is not conducted on the same plan as those of Germany. Before the Franco-German war, the name of Academy was given to what is now the University, although the number of students was then much larger than at present. Strassburg has for a long time been the residence of distinguished scientific men. Of the botanists of the old régime, Schimper and Buchinger still remain. Millardet, the most promising of the younger men, is now in Nancy. Prof. Schimper, perhaps the most distinguished member of the scientific faculty, still gives lectures on fossil botany and has a very large and rich collection of fossil plants.
>
> The active botanical work is performed by Prof. De Bary and Ass. Prof. Solms von Laubach with Dr. Fritz Sc[h]mitz as assistant in the laboratory. The number of students attending botanical lectures, if we except the course on Medical plants, which must properly be included in the medical department, has never been greater than fifteen and quite frequently not more than five. The attendance has sometimes been as low as two. I give these numbers simply to show how different are the conditions from those of our own universities. An American professor would hardly think it worth his while to deliver a lecture to five students. The different proportion of instructors and students affords the clue as to how the Germans are able to do so much high scientific work. The professors have very little else to do. It is for this object that they are appointed professors while in America the professors are only able to do any purely scientific work in intervals between long courses of elementary instruction which is done in Germany in the gymnasium.

Farlow began his own studies at the laboratory in October, 1872, and he described his work in two letters to Gray.

Strasburg, Oct. 6.

Dear Sir;

. . . I have now been in Strasburg five days in my rooms, up four flights, in the Hotel Allemannia. Every day I go to the laboratory where there are three other students besides myself: a young man, quite young [Rostafinski] who is a genius. He draws and paints very well, and is now at work on a book on the Myxomycetes; another, a native of Strasburg [Gilkinet] who is skilful with his fingers and a third, somewhat older [Suppanetz] from Gratz who is doing something or other with Pediastrum and some of the Desmids. The first two students have been with De Bary three years.

Prof. De Bary is a very good teacher. He is very thorough. He put me, at first, on to Chara and makes me draw everything with a camera. I find it rather slow work, and am afraid I shall have to stay two or three years with him to learn much, which is longer than I think I shall be able to. Here every one thinks that a knowledge of the larger fungi or algae is contemptible. That the only thing worth living for is to study the development of some of the lower forms. A sys-

tematic botanist of Fungi or algae is regarded as a shallow person, of course, without any ability . . . You will be surprised to hear that I have come to the conclusion that England is, on the whole, the best place to study as they have not such a mortal dread of anything systematic. I should like your advice about what I should study.

W. G. Farlow. Hotel Allemannia.

Strasburg, Nov. 1st. 1872.

Dear Sir;

. . . I have now been a month in the laboratory but the lectures did not begin till this week. The lectures I have decided to attend are, De Bary's on Vegetable Anatomy and on the Lower Forms of Life, Graf Solms on Cryptogamia, and Schimper on fossil botany. Each lecturer lectures three times a week. Graf Solms has the uncomfortable hour of 6 to 7 in the evening. None of the lectures begin till a quarter past the hour. When it is light and I am not at lecture, I work in the laboratory, with the three students that I mentioned in my last letter. At first, I had the development of Chara and, then, started on vegetable anatomy, first, with the sieve cells, which are interesting, and, now, I am studying the milk ducts in Euphorbia, a tedious but not uninteresting work. There is a new monograph on the latter subject by David, a pupil of Cohn. The probability is that I shall devote six months to anatomy and then take the Myxomycetes. At first, Prof. De Bary gave me as much attention as I could desire, but, lately, he has been entirely occupied by his duties as Rector in matriculating the students. He told Rostafinsky that he should soon be able to devote considerable time to me, which will please me very well, as I don't like his assistant Dr. Schmitz very well.

De Bary is an excellent instructor and a very pleasant man. The students all like him. His German is a little peculiar and it is hard to understand him but he speaks very good English. He has not much mechanical or artistic skill but he is business like and doesn't poke like most of the others. As a lecturer he is poor. He doesn't speak distinctly, doesn't draw well, and is not at all interesting. Here, there is nothing to learn in the way of addressing an audience. The Professors have a very careless way. De Bary's audience consists of five persons. Graf Solms, as he is called, doesn't speak English at all. I understand his lectures very well and they are interesting. He seems to be a very industrious man and very well trained in microscopic anatomy and the general structure of the lower orders. I should hardly think that he knew as much about flowering plants as was necessary for such a position as he has. He also lectures on Pharmakognosie but I don't attend. His delivery is somewhat better than De Bary's but still he is not a model. He has an audience of six . . .

On Wednesday I was matriculated. The imposing ceremony consisted in listening to a short poorly delivered address from Prof. De Bary, who is rector, then shaking hands with him, and receiving a ticket of admission. There are, now, about three hundred students in the University. I have to pay for lectures and laboratory 120 fr., not including Prof. Schimper's lectures which have not yet begun, and for which I have not paid. Schimper is, it appears, a fine zoölogist and geologist as well as botanist. He is attached to the zoölogical department . . .

Yours, in haste,

W. G. Farlow

Farlow had not been long at Strasbourg when the opportunity arose for him to acquire, for his personal herbarium, his first famous collection of fungi. Before he left America he had discussed with Gray the possibilities of buying the Curtis Herbarium, and in October he received the following note from Gray.

Cambridge Oct. 16, 1872

My Dear Farlow

We have much enjoyed your letters — the last from Berlin, & including several of the Linné photographs. They are *most delightful*, and I beg you will keep up the habit of so writing to me. When I can I will write to you in return . . .

When you left you were a good deal disposed to acquire the late Mr. Curtis's coll. of *Fungi*. Mrs. C. is now ready to divide the Fungi from the rest and to take *$1000*. I have to-day seen Mr. Sprague of Boston who advised my securing them, and offerred — long ago — to pay $500 towards it. He tells me that he is now in different circumstances from what he was, and wishes to forego the purchase — don't think he can afford to pay $500 at all. And putting in the *steam*-warming here has used up the means of the Herbarium for last year & much of this year.

So, if you are still very fungously inclined, and want to be *set up* in this department, I am out of the way, and you can buy the collection if you will. What say you? If you decline, I shall offer it to the British Museum.

Ever, dear Farlow,

Yours sincerely,

Asa Gray

Farlow replied promptly (November 1):

As to the Fungi, I have concluded to take them. The price seems to me to be a fair one and, although I know nothing about fungi now, I hope to some time hereafter. The collection is unique and certainly should not leave America. I think it will be worth a thousand dollars to me as a recommendation in securing a position when I return. It is something to possess the finest collection of fungi in America and I hope, before long, to have a good collection of algae, certainly the best in America . . .

I will write, at once, to my father about paying you for the Fungi and will ask my brother to call and see you about the payment. What shall be done with the collection? Had I better have it sent to my father's house? How can it be forwarded to Boston? I will ask my brother to settle these questions with you.

Cambridge Nov. 25, 1872

My Dear Dr. Farlow,

I received your letter — saw your Father, same morning — wrote to Mrs. Curtis — and now have this reply: —

Will attend to all . . .

Ever yours,

A. Gray

Gray enclosed in this note the letter from Mrs. Curtis.

Wilmington. Nov. 22nd. /72

Dear Doctor Gray,

I have this morning received your last letter, forwarded to me from Hillsborough, and hasten to reply, lest you should imagine me doubly neglectful. The former one, advising us to pack and forward to you, the books relating to Botanical science, left by my dear Husband, was received a few days before I left for a visit to my friends in this place, and it was scarcely possible to write just then.

I shall return home in two or three weeks, and will try to pack the Fungi, as you wish, although it is a subject for regret to all of us, that the Collection must be separated. When we have all arranged to send off, I will communicate with you again, and let you know in what manner to make the payment.

With the greatest respect and regard, I am, dear Sir, Yours,

M. De R. Curtis.

Farlow acknowledged Gray's kindness in offering to look after the collection, and in the same letter expressed his rather dubious opinion of De Bary's way of running the laboratory.

Strasburg, Dec. 19th.

Dear Sir;

I received your letter with the accompanying one from Mrs. Curtis a few days ago and am glad that you have consented to see whether the collection is in proper order although, I am afraid, that it may take more time than you ought to give. The collection of M. De Brebisson is for sale in fragments and I have ordered Cape and S. American algae to the extent of a few dollars. His collection of diatomes is very good and is supposed to be worth 2000 Thalers. A Dutchman I believe is going to buy it.

. . . As a whole, the laboratory looks about as much like a chemical laboratory as a botanical, since there are any quantity of bottles of reagents, test-tubes, evaporating dishes and a great hood. There is an immense amount of strong 40 p.c. alcohol used as everything, even algae, are put into it at once and we have each a small wash bottle full to moisten our sections every few minutes.

In some things they are deficient since there is only one drawing prism and one Redresseur and, what is abominable, not a single dissecting microscope.

On Monday next, begins a recess of a fortnight and I am going to Frankfort for a few days to rest, and, then, shall come back to study. I have now been here three months and can form an opinion of the merits of Strasburg. As far as the town itself and social advantages are concerned, it is detestably bad. It is a very bad place to learn any language and there is no redeeming feature about it. As far as the botany goes, sometimes I am satisfied and sometimes not. From what I learn from the other students, what I regard as deficiencies in the instruction are common to all Germany and not peculiar to this place. Everything is slow to me, but, then, I am in Germany. There is no *plan* of instruction whatever. That is, I must know what I want to study and ask for the material myself and go to Prof. De Bary as I would to a dictionary, for information. I have learnt, as have all the others, not to ask Dr. Sc[h]mitz questions, as the answer is more perplexing than previous ignorance and, when he comes round to ask what I am about, I tell him I have material enough to last for some time. I never let him

know that I want something more for, in that case, he picks up the first thing that comes handy whether it has any reference to my previous studies or not.

About eleven, Prof. De Bary comes into the laboratory for a little while and, generally, again late in the afternoon. He knows a great deal and is very pleasant but is very often interested in abstract propositions which no one but a German cares anything about. A fortnight ago Dr. Schmitz gave me a Lycopodium Selago to study and, after making sections and preparations of one kind and another, I thought I knew it pretty well when De Bary asked whether the capsule arose from the stem or the leaf. After two or three days' work I managed to get sections which satisfied him and, of course, myself that it arose from the leaf. Then came the question how it arose which he didn't know or, as far as I can find out, anyone else. After much more labor, I discovered that the epidermal cells begin to divide parallel to the surface and it grew out in that way. Then came the, to me, transcendental question what might the subepidermal cells do, and, for a week, I made section after section of the Vegetationspunkt with no result whatever till I used up a great bottle of material which put a stop, fortunately, to further investigation. I ventured to suggest to my neighbors that I thought, as I wasn't to stay in Europe forever, that my time might be better employed than searching for a needle in a haystack which I could do as well at home. My Alsatian friend, from whom I learn more than anyone else, said Oh! in a few months you will be able to write a monograph on the subject. That remark was a clue to the whole thing; they study for the sake of writing monographs, just what I don't wish to do here. I can do that when I get back . . .

Remember me to Mrs. Gray, and all the gentlemen in the herbarium.

Yours, respectfully,

W. G. Farlow

Farlow was always on the lookout for books as well as specimens which would provide him with a good working collection when he returned to America. He browsed through every available bookshop and catalog, and gradually accumulated for himself and for Gray an enviable collection of the best botanical books in Germany. By the summer of 1873 he wrote that he had a trunkful of books which he would like to send home, and the following summer he observed with some pride that as an added qualification for a position he had "the Curtis Fungi and the finest collection of algae and algological books in America and a good collection of modern works on fungi." Many of his letters to Gray contained reference to books which he had seen on the market, as well as observations on the usefulness of some of the newer works.

[December 19, 1872] Books are uncommonly dear, it seems to me, and we get German books in America very nearly as cheap as here. Among books which may interest you, are Thomé's of the Real Schule, Cologne, Lehrbuch der Botanik. He has also written a Zoölogy and both books are the standards in German schools. In the Botany, the plates are very good and he goes into the anatomy and Cryptogamia much farther than in our own text books, and, I think, too far for common school scholars. But that is a German failing. The third edition of Sachs Lehrbuch has just appeared. The principal change is in the article on Aleuron. The Lehrbuch in Germany is a sort of botanical Bible and there is no use in telling a German that there is a great deal in it that is stupid

and had better have been omitted particularly as it is borrowed from Hofmeister. A book which I am going to buy sometime and which would be a great help in your lectures on Economical Botany is Berg & Schmidt's Officinelle Pflanzen, in four moderate sized volumes with very good colored plates. It costs, I believe, 26 Thalers, a pretty high price.

[January 4, 1873] A book which I shall buy for myself and which, certainly, ought to be in the Cambridge library is Tulasne's Carpologia Selecta Fungorum, of which, if I remember rightly, you have only the volume on the Tuberacei. It is expensive, coming to, at least, fifty dollars, perhaps more. Another work, which I, possibly, mentioned in my last letter, is Schimper's Paleontology in three volumes, in French and horribly expensive considering. It is 30 fr. a volume, I was told. Strasburger's Coniferae & Gnetaceae is regarded as a good morphological work, that is, a book which nobody ever finds time to read.

The algae of De Brebisson which I ordered were previously engaged. I think, before I come home, I shall get Fuckel's Fungi Rhenani and Rabenhorst's Fungi Exsiccati unless they are already in Curtis's collection. Have you Rabenhorst's Characeae? I have been advised to get them. Dr. Schmitz has sent you his article from the Flora and I asked him also to send Mr. Wright a copy.

I spent Christmas week in Frankfurt stopping at the Hotel du Nord but spending most of my time at the Consul's Mr. Webster, father of the only real American in Strasburg besides myself. I went into the store of Joseph Baer and spent some hours looking over his books. He has a Jacquin's Flora Schönbrunnensis, in good condition for 68 thalers, a Hooker & Greville which Prof. Eaton may like. I bought Martius's Plant. Crypt. Brasil for $18, Mohl Vermischte Schriften for $1, Boerhaave's Historia Plantarum Lugduni-Batav. 1731, Dillenius Cat. Plant. Circa Gissam 1719, for 50 cents, the two last simply as curiosities. I found a Vegetable Materia Medica of the United States by Barton, Vol. 1 for $1.50 and bought it. I don't know whether a second volume was ever published. Michaux's Flora Am. Bor. 1803, 2 vols for $3.00. There was a Barton's Flora of the United States 1st vol. complete, and second not bound and not certainly complete for about $10. I couldn't find out how many plates ought to be in the second volume. If I had been sure that it was complete, I should have bought it for you as I heard you say you wanted it. In Mrs. Curtis' letter she mentions sending her husband's cryptogamic books to you. Have you bought them for the library or is there something which I ought to purchase?

If I felt sure of getting a permanent position at Cambridge, I should limit my purchases of books to those which, as far as I know, are not in the library at Cambridge. But, as it is, in consequence of losses by the fire, I suppose the college will not feel like increasing the number of its instructors for some time to come, so I must buy books which will be necessary if I go to a place where the library is not as well stocked as at Cambridge. The same feeling interests me in collecting. I don't want to preserve the phaen[er]ogams which I may collect but the knowledge that I have a collection of flowering plants will help me in getting a position in some other place than Cambridge. The fungi and algae, of course, I save and perhaps I shall the mosses . . .

[March 6, 1873] Last week I saw a catalogue of Moser in Tübingen with some excellent things remarkably cheap. I wrote at once but found the best things gone to my regret. I bought several pamphlets, on algae principally, and an Endlicher. I saw a copy of Sprengel's Das Entdeckte Geheimniss, which I know you wanted, but it had been sold unfortunately. I agree with you that single odd

volumes are a delusion and a snare. About De Bary's work every day something of his which I have never seen before turns up. As I expect to be here next term I shall secure more of his pamphlets for myself and next week I shall buy some of those for sale. Perhaps, when the photographs arrive will be a good time to suggest that he should send you a complete set of his works. Brefeld's Penicillium has just arrived in manuscript with ten plates said to be very interesting. Strasburger's Azolla is like all his works but I don't believe you will want it. Rüssow, a Russian, has written a book in German on the structure of higher cryptogams which I may possibly buy but I don't think you will want. Have you Schwendener's Flechten-Thallus?

[May 12, 1873] I have just ordered and secured! Sprengel's Entdeckte Geheimniss which I know you wanted. At last, I have got hold of a Postels & Ruprecht for 32 thalers in Berlin.

[June 30, 1873] A copy of Corda's Icones Fungorum is for sale and De Bary has told me that it is an indispensable work and advised me to buy it although the price is 130 Thl.

[November 15, 1873] Ruprecht's Tange, I bought before I left Cambridge. Eaton wants to use my big Postels & Ruprecht until my return and I shall write to my father to mail it to him. I have lately bought a few books and shall order more. I expect soon a Tulasne for 60 Thl. Two indispensable and unfortunately unprocurable books are Corda's Icones Fungorum and Sowerby's British Fungi. A Corda was sold last year for 130 Thl. Is there a Corda in America? Sowerby is in the Bost. Nat. Hist. I now have a good many pamphlets which have cost a heap of money. However, most of them are very useful and not to be found in America. Is the set of Pringsheim's Jahrbücher in Cambridge complete? I shall try to get De Bary to let me have his duplicate set, not quite complete, of Fuckel's Fungi.

[June 13, 1874. London] De Bary has bought Duby collection. I have bought Sowerby's Fungi and a Harvey for my own use. I can't make up my mind to give $200 for Kützing's Tabulae Phycologicae. I feel more like giving $80 for a Bulliard which is very useful for fungi and not often to be had.

After Farlow found himself more or less oriented to the German way of research, he began to shape up more definitely his own plan of study. His language difficulties, coupled with his intense dislike for Strasbourg, brought up the question of whether to stay on with De Bary, or to move to some more congenial city. Some of his problems were settled when, early in January, he received a number of suggestions from Gray who, kept at home by an attack of influenza, found himself with plenty of time for planning.

Cambridge Jany. 10, 1873

My dear Farlow,

Yesterday came another of your welcome letters — to solace me in *illness*: for I suffer with a dreadful influenza — & Goodale is away, at Baltimore.

While lying sleepless I have thought over your studies &c —

We are going to have the Cryptogamic Flora of U. S. done up, pari passu with the Phanerog. Sullivant is *engaged* to do the *Mosses*, in a volume — to which I hope to have Austin do the Hepaticae.

I want you to come home prepared to do —

1. The Algae — one vol.
2. The Fungi —
3. — since they are only *Algae & Fungi!* either dwelling together — or the lamb inside of the lion — you will probably have to do the Lichenes! Unless we can get them out of Tuckerman, in an intelligible form — which is doubtful. He is somewhere among your friends the *Germans*.

I should think you are doing pretty well — learning what you ought to know — getting the ways of working. But tell De Bary that if you stay there another *semester*, you must be put at work on & be taught *Fungi*. Of course, only low Fungi could be noticed there — or could be worthy of notice by your philosophers, such as the mould upon a Strassburg cheese or a bad-smelling sausage: *Wurst* — I think they call them, which is descriptive when spelled with an *O*.

If De Bary can't see that you are taught this special lore, why, I would migrate in due time . . .

I doubt if Hofmeister has ever been much of a teacher. Yet I always thought much of his work. I suppose your best chance would be with Nägeli. If they find *him* intelligible, there need be no despair anywhere.

Tubingen should be a cheap place to live, and a complete University town. Hegelmaier who worked up Lemna & other low Pha[e]nogams is a *Botanist*, and I should think you might learn much of him, as to ways of research.

Suppose you look in at Tubingen & see a little for yourself.

Munich is cold enough in winter, but an attractive town. *Nägeli* conducts a well-ordered botanical laboratory. Radelkoffer, his aid is a jolly good-natured man, who knows plants & flowers somewhat, as well as vegetable anatomy. So, I should be content with Munich for one trial.

But I have a capital idea for you when your summer vacation comes — Dr. J. Müller, Candolle's curator, at Geneva, is one of the best *practical* workers at *Lichens* &c. — the very man to initiate you into *Lichen genera* & Lichen work. When summer or spring arrives go up there, and arrange with him to take you in hand, & have with him, & De Candolle, & Boissier your respect raised for *Botany*. In 3 weeks of work with Müller you would learn *Lichens*, and Geneva is the place of departure & return for the Swiss excursions you will enjoy . . .

They are going over the collection of Fungi, Mrs. Curtis & son, — and in reply to a letter, I insisted that they were to see that all was thoroughly poisoned or repoisoned!

Get as many of the Lehrbuch's as you think worth while . . .

Oh — as to *Cohn* at *Breslau*. I think you might do well with him, for a while, as you say. And then, if Goeppert is not too old you might really learn somewhat of *fossil-plants* — which you never would from Schimper's lectures.

But I have another good idea. Get *Schimper* in a series of private lessons, as the days get longer, to put you up to *Musci*.

He is an old & famous hand at that, — and you might learn all his *wrinkles* in a fortnight.

Mrs. Gray is as much broken down as I am — & suffers with, what Dr. Wyman assures us is Pelliosis rheumatica! — I, with *influenza diabolica!*

Always Dear Farlow,

Yours truly

Asa Gray

Farlow replied on January 27.

. . . I am very sorry to hear that you and Mrs. Gray are sick. I had hoped that, with the better heating of the herbarium, you wouldn't be liable to attacks of bronchitis as before. However, I suppose, you are glad that Mrs. Gray is sick, since misery always likes company.

I was glad to get your advice about my studies. In a week or two I shall have finished my anatomy and shall then go on to Pilze. So far, my regular study has been anatomy but I have made occasional excursions into other branches. I learn a great deal, also, from the studies of the other students who always show to me what they have interesting. Stahl is at work making a lichen out of a fungus and an algae. I have now saved about 70 microscopic preparations which will be of very great service to me as I know exactly what points each specimen illustrates. We are taught to make very thin sections, no matter how small or ragged they look. I think I could stay with De Bary another term to study Fungi and Conjugatae and lower algae. Strasburg itself, however, is utterly unendurable and I find it fearfully hard to learn the language here. I had some thoughts of going to Bonn to spend the summer semester and study botany only forenoons and the language afternoons and evenings. I must learn the language at once. If I was in a private family and could give my whole time to German, I could get it. As it is, my best energy is spent entirely on botany. Your letter however, changes my plans. I must decline going to Tubingen or any other small town in South Germany until I have learnt the language better. I hope to study in Munich next winter. Your statement of what I am to learn hardly comes within the bounds of your usual modesty. I think I could stand the algae and, in course of time, the fungi, but, when you come to add the lichens, I begin to despair. I should like, as you propose, to study in Geneva and should like a letter of introduction to Mueller if you feel inclined to give me one.

As the term neared its end Farlow was able to estimate the value of the courses he had studied, and he seemed suddenly to find a surprisingly large number of reasons for enjoying his work at Strasbourg. On March 6 he wrote:

. . . For myself, the most interesting thing at present is that the semester will end next week and we have a recess of about six weeks, till May 1st, when according to all appearances I shall return to Strasburg for the months of May and June . . .

I like De Bary better and better the more I know about him and the students in the laboratory are pleasanter than I can again expect to meet in any one laboratory. Rostafinsky leaves and goes to Munich where I shall meet him again. Suppane[t]z also leaves to secure an appointment in Gratz. Döbrach goes to Bonn, but he was by far the least interesting of all. Gilkinet and Stahl remain but go with me to Munich next winter. Besides the botanists, I have only one acquaintance in Strasburg of any account, that is Webster, the American law student.

As to my studies (in botany not German) I suppose I am as near satisfied, as I, who am a first class grumbler, can expect. I have been over anatomy practically and by lectures very much more thoroughly than ever before and there is but one point which I have omitted which can be better studied in summer, the development of the embryo. I have about a hundred preparations and some

Anton De Bary

Ernst Stahl

Alfred Gilkinet

Josef Rostafinski

Plate II

drawings which will be of use to me and what is most important have learnt the German way of work and managing a laboratory which is radically different from ours. Lately I have been at work on the Pilze and their development in which branch De Bary has more practical knowledge than anybody else in the world. He is very pleasant and takes an interest in his students and gives them a reasonable amount of time and attention. I have studied the potato disease, Mucor and the allied forms, Piptecephalis and Chaetocladium, Ascobolus and Eurotium as types of Sphaeriaceae and Dictyostelium mucoroides. The last was particularly interesting from sowing the spores till the ripe sporangia were produced on the object glass. De Bary spent an hour showing me the original preparations of Brefeld's Mucor and Hallier's cholera Pilze, the latter very shabby, dirty and composed principally of striped muscular tissue. Incidentally I have examined other fungi, Uredineen &c. My neighbors in the laboratory are very obliging and help me in any way they can.

Next term, De Bary has two courses, a course on general anatomy which I shall not regularly hear as it is too simple, elementary, and once a week on the important medical plants. Graf Solms has two courses on Systematic Botany which I shall attend, if they are good, and on Phaenogamic Parasites. With regard to Schimper I don't think I care to study the mosses with him; he is learned but now old and a little tedious. I could learn nothing from him in a short time. I may instead study lichens with Graf Solms one or two afternoons in the week as a relief to the Pilze study. With De Bary I shall study only fungi and their development and leave the algae for Munich or, if I am so lucky, Thuret . . .

I have taken tea twice at De Bary's and a few Sundays ago all the botanists were invited by Gilkinet, the Belgian to dine. De Bary was there and we sat down to the table at one and rose at half past nine, a fearful feed. At the beginning each guest was provided with two enormous bottles of wine, and, when these were disposed of, more was brought on . . . Next week, I believe, Rostafinsky is to give a dinner.

Farlow derived a great deal of pleasure and no little amusement from his contact with De Bary's assistant, Graf Solms von Laubach. He described him as "a strange man, good hearted and well meaning but very awkward and, as a Graf, filled with strangely absurd stories about America." The Graf, however, was not the only one to have extraordinary ideas of America, because Farlow remarked in one letter "I am not unfrequently asked whether our lectures are in English or German by intelligent people. I have, also, been asked if it wasn't very pleasant collecting near Boston because the Gulf of Mexico must be a very good place for sea-weeds." At another time he told of meeting Müller's young son, who had recently been reading Cooper, and was "delighted to see some one who could tell him all about the Indians of Boston." Unfortunately Farlow did not elaborate upon the Graf's conception of this country, but he has described how he enlivened the work at Strasbourg. In a letter to Mrs. Gray (October 27, 1873) Farlow told of a collecting trip to which Graf Solms contributed most of the entertainment.

PLATE II. Contemporaneous portraits of Anton De Bary and three of the laboratory students with whom Farlow associated at Strasbourg.

Day before yesterday we all went on an excursion to the other side of the Rhine to a village called Kork. First, of course, we had to have some dinner and Graf Solms, who is one of the most awkward and amusing men I ever saw, began by upsetting his soup all over his clothes which was followed by a volley of Donnerwetters and wailings over grease spots which never can be taken out, requiring all the skill of De Bary to quiet him. The rest of us were so convulsed with laughter that we couldn't say or do anything. We all ran for the train and had to pay a fine of 50 ct. for coming so late. Kork is a flat plain interspersed with mud puddles and ditches and here the Kork youth with woollen night caps watch large herds of swine and geese. We proceeded slowly through this charming region the only question as to how wet we should get. At length we came to a very dirty pool full of different species of Elatine and Graf Solms began digging in the mud and screaming every time he fished up an Elatine to the great delight of all the swineherds and De Bary who called the plant Elatine spectaculosa in consequence. Another pool was full of Marsilea and the botanists all lay down flat in the muddy grass and began digging up the mud with their fingers and my umbrella, Graf Solms screaming at intervals and jabbering mixed French and German. When we were all dirty enough to go home, he discovered that he had not worn his excursion shoes which distressed him exceedingly. His troubles were drowned in a glass of beer at the depot.

As to his lectures, Farlow said (February 4, 1873):

Graf Solms I don't like particularly well on the Cryptogamia. He is now on the algae, of which he has made a perfect botch. There is no classification of the algae to be allowed because the 'Entwickelungs-geschichte' isn't well enough known; therefore, by German logic, Graf Solms is not to have any system in his lectures, in which negative point of view his lectures are a perfect success. Today a specimen of Gracilaria was passed round to illustrate Gigartina compressa and Wormskioldia was described as Delesseria. Porphyra was also in Florideae. The mixture was so bad that I don't wonder that the students here, not one of whom has ever seen the sea, think that the algae are in a wretched state.

Later he wrote (March 6, 1873):

Lately he [Graf Solms] has been lecturing on the Pilze and as his lecture room is next to De Bary's private laboratory he was afraid De Bary might hear his mistakes so that he has lectured in a whisper for some days to our great amusement. His greatest fault is that he has no system about his lectures but perhaps that is because he is an aus[ser]ordentlich[er] professor.

There was some thought at this time of calling a European botanist to Harvard on Gray's retirement, and this possibility made Farlow wonder about his own prospects after his return to America. Fearing that Harvard might not have a place for him, he asked Gray about the opportunities in California, saying that while he preferred to be in Cambridge, he was not "of the number who believe that all colleges but Harvard are barbarous." Gray, in his letter of February 23, 1873, hastened to reassure him. He wrote:

Take your time — prepare *thoroughly*. Meanwhile, if you get in a hurry — and if, as is likely any other place turns up — and places are sure to turn up — I will see to your interests all round.

Do not be at all uneasy. By the time you are ready there will be some good place for you. Anyway as soon as you come back there will, at the least, be an assistant-professorship here for you, I cannot doubt.

But your winning card, as it is what is *most wanted* in U. S. is Cryptogamy — especially low Cryptogamy. *Fungi* will be the most telling card. There you will have an exhaustless and a *popular* field — in which, well prepared — you can make a mark here.

Algae — are well, but marine soon exhausted . . .

Then *Lichens*. Tuckerman is hors de combat, I fear. You must really go into them! And, indeed, when Sullivant goes off the stage — which *must be* before very long — there is no fit moss-man.

Whether you should stay at Strasburg longer I am not competent to advise. I should say stay if Strassburgh were a pleasanter residence. You are just now entering upon the field in which De Barry can teach you much, & I hope would do so. But you must take the universities in their turn.

Perhaps in some you will find good *lecturing* — which is also to be studied. Perhaps you must go to France for that. The French '*expose*' best.

. . . We were *so* amused with your account of Solms' lecture on Algae. If you stay at Strassburg, you had best be a *Privat-docent* in *Algae*. It would tell!

Farlow replied gratefully on March 24:

Dear Sir;

Yours of Feb. 24 was received a few days ago and I was even more glad than usual to hear from you. Of course, there are times when I feel anxious to know what I am to do when I get back and that anxiety does not help my studying for the present moment, but, as long as I feel that there is some one who has an eye to my interests, I do not feel so much inclined to hurry up my studies here. I cannot express my obligations for the expressions of interest in me contained in your last letter.

There are evidently two ways of studying the botany. The first, to catch the plan of work in different places and then myself to transfer that plan to America. With such an object I feel as though I had already had enough of Strasburg. I know De Bary's method of investigation and could apply it at home — if I had time. A term with Nägeli and a short time with Hofmeister and two or three months in France would teach me the methods of study adopted by European botanists and in a year and a half I might come home, not so very badly prepared, at least, to tell what other people are doing.

The second plan involves in addition a continuous work under the different professors and requires, I am afraid, double the time required by the first mentioned course. In pursuance of this plan, the most thorough and the one I should rather adopt, if I could spare time, I ought to stay longer in Strasburg. Accordingly, when I left Str. a week ago I told De Bary that I should probably return for the months of May and June. I left my preparations and microscopic affairs there. Next winter as I have said, I expect to go to Munich . . .

If you were amused at the account of Solms lectures on the algae you would also have been amused at those on the lower fungi. He told us that we must regard the Myxomycetes as animals for he didn't have time to lecture on them. If he had had two more lectures he should have made them out to be plants. He tumbles over his chair puts his fingers in his mouth and goes through contortions that would make a cat laugh. He is goodnatured however. Just before

I left Strasburg I invited all the botanists, eight in number, to dinner. De Bary was at one end of the table and I at the other and Graf Solms in the middle where he kept up his old habit of swigging down red wine. Suppane[t]z the Austrian was more blooming than ever and went into rhapsodies over some figs on the table, Süd-europäische früchte, Liebe[r] Gott, classische, colossale, ganz eminente. He flourished his knife in a way to make me fear for my life. The supper lasted, for Strasburg, a short time, that is from half-past eight till a little before twelve. The greater part of the company then retired to the Deutscher Kaiser to finish up with a few glasses (10 or 12) of beer. The laboratory broke up last week. Suppane[t]z is ordered by the Austrian government to Prague instead of Gratz where he will probably get a place; Rostafinsky went home, Döl-brach to Bonn and I cleared for Frankfurt. At Carlsruhe I ran into Graf Solms who was characteristically trying to back round a corner. He spent the time till we reached Heidelberg in repeating to me how 'komisch' it was that we had met . . .

You are getting so modest in your demands that in your next I expect to hear that I must study the ferns, as, in course of time, Eaton will depart this life, and possibly the flowering plants also. The lichens I should like to study and in Geneva where I understand one can learn French better than in Paris. However, I must first learn German, and it will be provoking to find that just as I am getting so as to be comfortably up in the language I must go home.

Rostafinski's plans of studying algae with Thuret raised the hopes of Farlow that he might be as fortunate, for, as he said "There is no one in Europe I should so much like to study with as Thuret." On receiving the letters of introduction which Gray wrote to Thuret and Müller, Farlow lost no time in sending them off to the two men, with his own request for permission to study with them. On May 12, Farlow wrote:

I had a very polite letter from Thuret saying that he should soon leave Antibes for the summer and he should be happy to have me meet him this summer in the vicinity of Nantes or next winter in Antibes. I accepted the latter alternative with pleasure . . . Thuret wished, in very polite language, to be remembered to you and Mrs. Gray.

Of the new semester's work he said in the same letter:

I omitted to write you, I believe, that, during the vacation, De Bary had a call to Vienna which he declined. Since then Sachs has also declined. It appears that the University in Vienna is on the decline in every department except medicine and there is so much intrigue and chicanery at work there that no distinguished men will accept positions. It was a disappointment to me that De Bary didn't accept, as I should have then spent next winter with him in V. and this summer have gone to Munich.

. . . I returned here at the beginning of the semester. I do not regret returning. In a social point of view, the laboratory is not so pleasant as last semester since Rostafinsky and Suppanetz are gone and Stahl is at home most of the time getting ready for his examination in June. A new Pole is here, a beginner, and three students who only work three afternoons in the week. But De Bary is capital. He has a general course from 8 to 9 which I don't hear and then is in the laboratory nearly all the morning. He pays me a great deal of attention. At

present, I am on the Uredineen and I am cultivating rusts and inoculating sound barberry leaves. I have an ergot Cultur underway but, I am afraid, the material is poor. Tomorrow I begin on Cystopus. There yet remain the fermentation pilze which I shall soon take up. We have all been catching flies for Saprolegnia and Achlya. De Bary began today on Medicinal Plants to a class of 36, a large number. It was simple and practical, in short, excellent. The same cannot be said of Graf Solms' lectures which I attend simply from personal attachment not because I like the lectures. Systematic Phaenerogams is a hurried humble-jumble and Parasitic Phaenerogams once a week, considering the materials which he has spent so much time and money in collecting, are not very interesting. He is soon going to publish something on the latter subject. He has several 'junks' of Rafflesiae in alcohol . . .

The semester opened a week ago, on Thursday. De Bary, as Rektor, gave an address, delivery abominable, substance very good. De Bary's personal appearance is certainly unprepossessing. Everyone says, at first, is that man really De Bary? In the evening was a torchlight procession in honor of the three professors who declined calls to Vienna. The scene was very interesting as the procession passed by the Cathedral to the Palace where the Professors addressed the students. Afterwards they all marched to the Kleber Platz and burnt up their torches in a heap and sang Gaudeamus as at the funeral of a Chor student. At ten o'clock began the Commers and lasted till nearly morning. I left at two. *4500* glasses of beer were drunk on this intellectual occasion. The singing was at first splendid, afterwards slightly confused. There were generals and professors and students all mixed up together drinking, all dressed as gayly as possible. Gilkinet and I sat in the gallery where we could see the whole performance. There were speeches, songs, Salamanders, shouts, howls, and above all drinking. The scene was new and interesting and I shall not forget it. Several times the waiter upset our table with several glasses of beer upon it. Fortunately, the beer ran over onto Gilkinet's side and he soon got to be tolerably wet. After a while I found myself about ankle deep in beer and concluded to find another seat. I am happy to say that I managed to get along without what is here known as a Katzenjammer or as the students say a Kater. In the course of the evening Graf Solms appeared miraculously in the gallery with Dr. Schmitz and we drank the health of the University. What that means I don't know. Afterwards the ubiquitous Graf wandered round the hall holding up an empty beer glass until after a while he lighted upon General Carminsky and the two talked 'Faderland' till morning.

A letter from Cambridge in June left no doubt that Gray was looking forward to seeing Farlow established at Harvard on his return to America. Gray also suggested that it would be well to begin to work up some special research which could be published within the coming year, and Farlow immediately responded to the idea.

June 9, 1873

My Dear Farlow

You know how very busy I must have been — and still am, with Goodale gone since May 1. So you see why I have not promptly responded to yours of March 24, from Frankfurt, April 23, Heidelberg, & May 12, Strasburg — And even now — late in evening, I can only write a line.

You seem to be going on famously well, and doing your best and wisest. I am glad you are back with De Bary. And I like the way you are laying out your work for summer and winter. Especially I am glad of Thurets kind response to you, & that you will get some time with him next winter or early spring . . .

Mrs. Curtis writes that she has sent the Fungi; but I have not yet heard if your Father has received them.

Goodale has been appointed '*Assistant Professor* of Vegetable Physiology & Instructor in Botany.' — his name will go to Overseers, I think to-morrow. The Corporation begin to be anxious about Bussey School — wants some Professors to work there — & are *determined to have students*. Things are shaping as fast and formally as I could wish, — and when you come home — unless you are called away by better offers elsewhere, you will certainly find something to do here. I see they are beginning to *want you*, and you may fairly count upon offers when you come home — very likely before. I have said, that you can't think of returning to America for a year yet — perhaps not even then — your time & opportunity in Germany too valuable.

I think it best for you — after consulting De Bary as to what — to get up some research which you can publish in Germany — or — still better — send over for me to publish here — in Amer. Academy — or in Amer. Naturalist — according to circumstances.

Then another thing will be very well.

Send home to me, from time to time, notices of interesting works or researches, Botanical news — criticisms &c — to be published with your initials among the miscellanies in Sill. Journal. Or, if you will write some sprightly letters on such matters that I can print in Amer. Naturalist, it will be well.

But lose no working time. Solid work is better than any display . . . All good things you can send me to print, under your own name, or initials — which will duly be known — will be advantageous . . .

Ever yours truly

Asa Gray

Strassburg, June 30.

Dear Sir;

Shortly after sending my last letter I received your letter of the 9th and the notices of the death of Dr. Torrey and Sullivant. I was quite surprised to hear that the latter was dead and I had no idea that he was so old a man . . .

I have spoken to De Bary about some special work. He proposed, The fertilization and fructification of Agarics, ditto of the Oscillariae, ditto of Scenedesmus and the Entwickelung (cultivation and growth) of Oidium lactis. The last I selected but, as one may work an indefinite length of time without meeting with any success or result, I have also taken as nebensache or collateral, the microscopic structure and growth of the Haftorganen i.e. the disks of Ampelopsis, and the rootlets of Tecoma &c. From one or the other I ought to make out something.

As for writing notices, I should be glad to do that and must try and find time in the vacations. The following subjects suggest themselves: late German Botanical Text Books, reviewing Sachs and Thomé, Rostafinsky's Myxomyceten; or, possibly, Cornu, Saprolegnieen and Strasburgers, Coniferen. For light letters, an account of Upsala, and botanizing in the Vosges. I might give a detailed account of the management of De Bary's laboratory and cultures but that is too much like letting the public into the secret . . .

I should like, after finishing my studies to write a compendium, something like Sachs, about Algae and Pilze, giving the latest modes of working and results so far as known. Such a book is very much needed as Berkeley is thoroughly bad and there is positively no other book in English. The writing would serve for me as a review of my studies and could also be available as a text book in classes where I had to teach the subject. The first thing, however, is for me to learn the subject myself. Remember me kindly to Mrs. Gray.

Yours, respectfully, but tired,

W. G. Farlow.

Farlow left in August to spend a pleasant six weeks in Geneva with Dr. Müller, and returned regretfully to Strasbourg in October, to take the last of the courses with De Bary which he needed to round out his studies there.

Strassburg, Oct. 27th.

Dear Sir;

I am again installed in Strassburg and, after Geneva, dislike the place more than ever . . . In comparison with other cities, it seems barbarous . . . I found my six weeks in Geneva very profitable. Dr. Müller gave me an unlimited amount of attention and I was surprised to find how much, with his help, I was able to do in so short a time. I have no means at present, to repay his kindness. Of course, I thanked him and gave him a book as a memento, but it would give me pleasure, if you should hereafter, if you have occasion to write to him, mention that I have written you that I feel under obligations to him for his attention and instruction. While in Geneva, I had an opportunity to make several excursions into the Jura and mountains near the city, in which excursions I succeeded in collecting a large number of lichens which are not only numerous but valuable, as I have studied them tolerably carefully, and, also, saved duplicates with an eye to future exchanges in America. Although, perhaps, having studied lichens under the most favorable and agreeable circumstances possible, I must confess that I think they are the stupidest and, at the same time, the most difficult plants I have ever studied. However, if it is necessary for me to study them in America, I feel as though I had had a good preparation here. During the summer, I find that I have collected quite a lot of Erysipheen, Uredineen, Perinosporeen, and the smaller fungi generally and have laid by a number of duplicates which I think will be of good service, hereafter, in America.

So far, although I have constantly regretted being obliged to shut myself up in Strassburg, I feel as though I could no where else and in no other manner have learnt so much of that part of botany which I needed to know and which is in America entirely unknown, certainly practically. I have now learnt so much anatomy, that is histology, that De Bary doesn't advise my spending any more time on it here. Then I have studied the orders of minute fungi tolerably thoroughly. Of course, to know the subject perfectly is a work of a life time. I have learned De Bary's method and, although a knowledge of forms and species is here discouraged, I have learnt a great many forms and, with the knowledge of their development and growth which I now possess, the determination of species comes tolerably easy . . .

The remaining botanical subjects which I wish to study are, the development of the higher cryptogams, i.e. the fertilization of ferns, Marsilea, &c; second, the algae, marine and fresh water in respect to their development, and physiology;

and thirdly, a short study of the cell, in the abstract, as has been done by Hofmeister in his latest work. Whatever I now study comes a good deal easier than it did a year ago, showing that the somewhat slow preparation recommended by De Bary is beginning to bear good results. I don't feel as though I wanted to stay much longer with De Bary. I should only be continuing the same work I have already begun. It is simply now a matter of detail and, if I am to stay here, till I know all he can teach I shan't get back to America for a long time. If I should stay here too long, I should be more likely to turn out a botanist of the Graf Solms type rather than like De Bary himself . . .

If I can return in September, as I hope, the question will be whether to go to Pringsheim in May, which will perhaps be decided in the negative if I study fresh water algae with Thuret, which may be possible, or to go to Würzburg where Stahl and Gilkinet are going, and study the cell under Sachs and attend his course on general Vegetable Physiology without actually going through the experiments in his laboratory. In this way, I should get all the Physiology necessary for me as a cryptogamist. Brefeld is also a physician in Würzburg and is now studying hefe pilze and, perhaps, could help me some. I hardly think I should find it profitable to stay more than two months in Würzburg. Afterwards, there is nothing which I care specially to do but, perhaps, to visit Rabenhorst, of whom both De Bary and Prof. E. Fries have a poor opinion. Then a few days on the coast of France or England and a visit to the leading English cryptogamists . . .

I think now I have stated the whole story. I should like to return next fall. If it is necessary for me to remain a year longer, I must simply spin out longer the list of studies I have mentioned and, possibly spend a short time with Strasburger in Jena, and, although I should at the end of that time know more botany, I should, perhaps, be less qualified to teach in America. Whether, as far as America is concerned, the opportunity is good for my returning you know very much better than I. I think you also know from a former letter of mine that, although I should like to return to Cambridge, I don't feel as though my future success entirely depends on it. As I then wrote, I should like also to go to either New York or California should there be opportunity in either place. At any rate, I feel perfectly safe in trusting to you, knowing that you will recognize what is for my best interest.

Here in the laboratory are Stahl, Gilkinet, and Carminski who remain, and two new students, Prof. Czerokin of Kasan, Russia, and Dr. Linsted of Berlin who has written on Saprolegnieen. After Christmas, Dr. Schmitz goes to Halle as Docent and Rostafinsky, who is now in Petersburg, may take his place. De Bary repeats his course on Anatomy and soon expects to finish his book. Graf Solms also repeats his Cryptogams. In accordance with your request I have written four gossipy letters for the Naturalist. I do not know whether you will not find them too light . . . I also send the promised critique on Thomé and Sachs. In a few days, I shall send notices of some recent magazine articles. I hope to be able to send you soon a critique or summary of the Lichen, algo-fungus question . . .

Farlow

These "gossipy letters" were edited by Gray, and soon appeared in three parts in the American Naturalist, vol. 8, 1874, under the title *Notes from the Journal of a Botanist in Europe. Part I. Sweden. Part II. Norway, etc. Part III. Geneva and the Alps.* Gray wrote on November 17:

I am arranging for the articles in Am. Naturalist — to begin in Jany no. Naturally enough these articles are not so *sprightly* as your letters. I wish you would write only on one side of your paper. I should like to *season up* the articles by *sandwiching* in bits from your letters.

On January 11, 1874, he announced their publication:

The 1st part of your *Notes* is in Jany Naturalist. It reads nicely. I have had proofs of the 2d — for Feb. number. I made it up out of your letters!

In the meantime, at the suggestion of De Bary, Farlow was at work on a new topic for research, which was to culminate in the much discussed paper on the discovery of apogamy in ferns. He first mentioned it on December 7:

Last week was rather an eventful one. I discovered an entirely new Puccinia on the common mallows in the botanical garden which germinates at this season. I presume De Bary will cultivate and describe it. My work has been the fertilization of ferns and a week ago De Bary found a case in Asplenium molle where the fern is produced directly from the prothallus without the intervention of an archegonium and fertilization. He gave that to me, as a subject to work up and I am now working busily away and have made quite a number of drawings. I shall finish the work as soon as possible for I want to go to Paris with Jackson about Christmas. However, I cannot leave till my work is completely done. It will probably be printed in the Botanische Zeitung and I will send you the same in English for the Am. Journ. if you wish. What shall be done about the figures? Had they better be copied from the Botanische Zeitung or shall I send you the drawings?

With regard to the letters I sent, it was difficult to say just how 'sprightly' I ought to make them. What I sent would here have been considered dreadfully frivolous. You did not say whether they wanted any more or not. You can make any insertions you please, but I don't want the editors of the Nat. to change anything.

With regard to sending criticisms or abstracts of magazine articles, now I am too busy with my paper to write any and if I am to leave sooner than I expected for home I ought to spend my whole time in study . . .

You will of course imagine that I am anxious to know what will be done in Cambridge this summer as my plans and travels may be so much affected thereby. If the college determines to introduce the study of cryptogamic botany I hope they wont forget that they must have microscopes. I think you will be disappointed when you again see me in the amount of systematic fungology which I have learnt but, on the other hand, I have studied development as applied to some of the minute forms, to a much greater extent than I should have ever done if I had not come abroad.

The work on the fern prothallus was not finished by Christmas, so instead of going to Paris, Farlow joined his laboratory friends Rostafinski and Gilkinet, in celebrating Christmas Eve with the lively De Bary family. On the following day he wrote his mother and sister his description of the festivities.

Strassburg, Dec. 25.

Dear Mother:

I take advantage of today to wish you all a merry Christmas. As far as I am concerned the day is Sunday intensified, that is very much quieter than Sunday is here. Last night we were invited to De Bary's to see his Christmas tree. It was all explained to me as though I had never seen a tree and Rostafinsky with his usual impudence and fondness for giving good advice hoped that I would introduce the custom into America. After the tree we had supper and at the end I was presented with a plate of candy on the top of which was a mock sausage for my benefit as I am so fond of such things. Today the weather is raw and foggy and I gave up my project of a long walk thinking the less I got of such air the better. This morning Rostafinsky made me a long call and this afternoon I called on Dr. Alexander and also took a look at the Vespers in the Cathedral where the altar was all lighted up. The soldiers had a tree in St. Thomas church but as there are 18000 soldiers I imagine that if one tree held all the presents a good many must have gone without. I should have liked to have seen the tree as it stood directly in front of the celebrated monument to Marshal Saxe which is very large and of white marble. Today the city has swarmed with soldiers and many of them being new recruits the uniforms looked clean and fresh.

Last Saturday I went to Frankfurt to see the Websters . . . In the evening a woman called who is keeping an American boarding house in Frankfurt. She had her pockets filled with great red apples she had received from America. After being so long in Strassburg the Frankfurters looked very swelly. The greatest treat at the Webster's is an American bed. That is, they don't have the feather plumons which the Germans always have. The plumon is a thing too large for a pillow and not large enough to cover me although I am not very long. Consequently as they don't have such things as bedquilts and comforters one's feet and hands are always out in the cold . . .

Your affectionate son,
William

Strassburg, Dec. 25.

Dear Mary:

Unless you consider yourself included in 'our' family I will wish you and your family a Merry Christmas. Last night I went to De Bary's to see his tree. I wasn't there at the opening at six o'clock being too busy to go so early. Mrs. Gilkinet was there and said there was a great running about and trying to look through the key hole. When I arrived I found the Norway spruce already lighted up. Instead of the hideous wax doll called the Christ child there was a bunch of gilded pine cones which Mrs. De Bary had prepared for the occasion. There were four children Wilhelm the oldest who was very sheepish and didn't say a word, August more lively, Marie, a rather too lively young lady six years old with a pug nose and little black eyes which are generally half strained out of her head by the two black pig tails on the back of her head, last night however her hair was flying in all directions, and little Hermann with very red cheeks and blue eyes. The presents were put on little tables near the tree. Hermann was perfectly absorbed and could not say a word all the evening. All the boys had a lot of soldiers. They seemed to have more toys than American children. Marie had only four dolls and a doll house besides a lot of other stuff and the older ones had books and games. The candies and cakes were a sight to behold and

came from all parts of Germany from Berlin to Strassburg. There was a young law student named Von Jacoby from Berlin who had a table with presents. He seemed to be a sort of protégé of Prof. De Bary's. He had an enormous mouth out of which he spilt his words. His conversation was principally about how much beer they could drink in his Chor. On his table were a lot of gloves, and such gloves. The Germans never wear any which are not ten sizes too large. There was an indescribable thing which Rostafinsky told me was a Pommern Gänsebrust and a great delicacy. It was a great goose skin sewed up at both ends and dripping with oil. It was full of uncooked smoked goosemeat and said to be delicious! The Pommern geese are very celebrated. There were also Erlangen Lebkuchen and Berlin gingerbread and two cans of condensed milk on his table. Mrs. De Bary had amongst other things two bottles of arrack punch. At the table the company appeared much interested in my description of peanuts which they thought couldn't be very nice and they couldn't understand how our You meant the same as their Du Ihr and Sie. They of course didn't see the point when I explained how senseless and inconvenient their Sie was. The other day De Bary had a great present from America. A box containing a swamp pitcher plant, some hickory nuts and twelve cranberries. As I said they were good to eat they cooked them and liked them very well.

Today I dined with Gilkinet. I asked if his little Georgie 11½ months old was coming home with his Alsatian nurse to spend Christmas. Ever since he was born he has been farmed out to a peasant near Strassburg. His mother didn't know whether he would be at home or not today but had an idea, she wasn't quite certain, that he was to spend the day in some village near the Vosges. Such independence in a child of his age would be remarkable in America. His mother seemed very calm and philosophical on the subject. So is Prof. De Bary who after giving Hermann a glass of wine before sending him to bed refused to let August, aged 8 or 7 yrs., have any more because he brought on a typhoid fever last year by drinking too much punch New Years.

Will.

A few more days of hard work brought the paper to its conclusion and on New Year's Day, 1874, Farlow wrote:

Today I send you the manuscript of an article on which I have been studying some weeks. I presume you will think it very short for the time spent upon it but all such work requires an everlasting amount of time. The article seems to me not at all adapted to the Naturalist but rather to Silliman's Journal. You are at liberty to dispose of it as you please provided, wherever it appears, the drawings are as good as those usually found in the Botanische Zeitung. I must make this a condition because when printed I should feel bound to distribute a few copies in this region and if the execution was not up to the mark there might be some very invidious remarks made about American publications here. I wrote the first draught in German and then afterwards wrote in English, having shown the German to De Bary. I have made a German abstract which will appear at once without plates in the Botanische Zeitung . . .

There may be a good many clerical errors in my manuscript but there is no English speaking person here to whom I can show it. I should like to see the proof of the figures I send before the article is published.

Gray acknowledged the paper with a brief note on January 11:

Your New Year letter, and the Mss. & drawings have come to hand. I write a hasty line to tell you so. I think of reading your paper to the Amer. Acad. And, if they will engrave the drawings to print in the Proceed. — otherwise in Naturalist unless Sill. Jour. will engrave on stone or copper.

We will see soon. Your paper is very interesting!

On February 15 Gray sent the first proof.

I read your paper to Amer. Academy — it is accepted for *Proceedings*. Here is a rough, unread proof. I may keep it back till I can get corrections from you.

That the figures may be photographed for the new process of reproduction, I have to get the drawings gone over in *pen* & *india ink*: pencil will not do.

Farlow returned the proof from Antibes, where he was enjoying at last his long anticipated visit with Thuret, and he protested that the drawings were not in pencil, but in neutral tint, and should not be inked over without his supervision. On March 21 he wrote again from Antibes.

A week ago I returned the proof corrected which you were so kind as to send me. Last night Rostafinsky and Janchewsky arrived and Rostafinsky said that the fern prothalli are now grown up into Pteris cretica instead of Aspidium molle. Today De Bary sent me a copy of the Botanische Zeitung with my short German extract in which he had changed Aspidium molle to Pteris cretica throughout. Will you be kind enough to do the same with the English or if it is too late for that, to write a little note at the end saying that in consequence of the further development of the prothalli enabling the species to be accurately determined it is necessary to change the Aspidium for Pteris cretica throughout. I thought myself that it was more probably Pteris cretica but De Bary thought the contrary. Now it is settled.

Gray replied disconcertingly that the "proof returned came *just too late*," and Farlow wrote again on May 4:

I reached Strassburg Saturday evening and, on my arrival, I found yours of Apr. 10th which had been forwarded from Antibes. I am quite anxious about the publication of my article as the preliminary remarks in the Botanische Zeitung have been attacked on all sides particularly in Berlin and Würzburg. I don't understand exactly what you mean by my proof arriving too late. I hope you do not mean that it has been published just as it was. If so, don't let a copy get into Germany for there were some horried mistakes in the quotation from Wigand. I hope also that the drawings are well done otherwise the remarks of the Germans, who don't believe the thing because it is contrary to their theories, will be disparaging to the last degree. For De Bary's sake as well as my own I must be extremely careful about the form in which the article appears.

The paper, titled *An Asexual Growth from the Prothallus of Pteris serrulata*, was published in the Proceedings of the American Academy, vol. 9, 1874, and the correction of the name to *Pteris cretica* had to be made in a note at the end. That Farlow was far from satisfied with the appearance of the article is evidenced in his letter of May 21 when he wrote:

As to the Fern Prothallus, I must confess that I was decidedly disappointed in the appearance of the plates which fall very far short of those in the Bot. Zeit.

and the criticisms have been so unfavorable on the execution of the plates that I hope you will not distribute any copies in Germany. I may have to translate and reprint the article with better plates in the Bot. Zeit. As it is, I shall have to leave any preparations, which I should like to take to America, with De Bary who will show them to other botanists. I hope you have kept the drawings . . .

As Farlow's sojourn in Europe drew near its close he became more anxious about what he was to do on his return to America, and although Gray hoped and expected to have a place for him at Harvard, there was as yet no official confirmation of a position. On March 27 Gray wrote:

Presdt Eliot is in England, till May . . . My *impression* is that he wished in spring to put you on to the Bussey-foundation, & do some work there — perhaps start a *fungus*-laboratory — as well as here. I'll be responsible that you get the full of an Assistant-Prof. salary . . . & in time more . . .

As the Bussey develops, I think it likely summer work may be in order there. But if so, you will have an equivalent in winter. Do not fear about that.

The President is getting a great idea of the importance of *research* — and will see that you have a chance. As to Goodale's course of this summer, — as you need not begin till *1st August*, I advise you to agree to come & take it then — give a month to it — if you intend to come home this fall at any rate. — If you think of staying another winter, that is another matter.

I think it will be for your advantage to take hold of this work next summer — tho' it wont amount to much. It makes the right beginning.

The last letter from Gray which we have of this long correspondence expressed once more his confidence in the establishment of a cryptogamic laboratory.

Cambridge May 4, 1874

My dear Farlow.

Yours of April 11, came while I was in Washington. What I & Goodale had previously written will by this time tell you all we can say. Presdt E. is not home yet, — but may be expected to-morrow.

I see you are decided to come home this summer, any how. In that case, I would, if I were you, get home before the end of July. But I would not hurry to be here sooner. The summer course this year will not probably amount to much, but will lay a foundation. The plan of Goodale taking it for July, & turning it over to you in August is best — You will then work independently. And you can go on into Sept. if you like. We shall, I doubt not be able to establish a laboratory for Cryptogamic & Anatomical Botany, in which you can make name & fame . . . Your paper has done you great service. More of them, and your success as teacher will do the rest . . .

I am sadly hurried — will write again soon.

Ever yours cordially

Asa Gray

Farlow sailed for home in June, 1874, and immediately received from Harvard his appointment as Assistant Professor of Botany. He entered at once upon the task of creating a laboratory in cryptogamic botany and

phytopathology, and his subsequent success at Bussey and later at Cambridge has fully justified the years of preparation that had gone into his European study. He continued to keep in contact with his friends in Europe, and his correspondence with De Bary was maintained until the latter's death. A letter written by De Bary in the summer of 1877 is of special interest, as by giving news of the whereabouts of the students in the laboratory, and of the completion of De Bary's own book, it brings to a natural close the narrative of Farlow's two years at Strasbourg.

Montreux, August 17, 1877

Dear Mr. Farlow:

From the stamp you will see that I have taken refuge in order to get peace, not in the desert like the ancient prophets, whom I do not emulate in general, but at that very corner on Lake Leman which you will remember as beautiful and quiet, especially at this time of year, because now people think it is too hot, while in winter the English and Berliners abound here. When you imagine this charming bit of land and water where redwood and giant trees, together with laurel, Laurocerasus, Punica, and Passiflora are being reflected in the blue surface of the lake, and right now the whole atmosphere is filled with the scent of the flowers of Ligustrum japonicum — while nearby the Phyllachora Congress is having its international meetings, and the wine ripens untouched by the disease these gentlemen are talking of — if you imagine all this, your heart will probably become reminiscent too, and you will forgive an old sinner inasmuch as he has retired to this idyllic spot in order to write you at last.

The narrator may proceed subjectively, so, I start with the news that the Anatomy is entirely finished four to six weeks ago, 640 plus 20 pages strong. I have been working desperately on it since last summer, except for a short interruption which I shall mention later. That's why you did not hear from me for so long a time. Two proofs which may have surprised you in April have been sent to you as a mute sign of life on my part . . . Since the middle of July I have finished everything excepting the last proofs. I have become human again, but I had to arrange and clean up so many things, and consider so many other matters that I could not find time to write a detailed letter.

The cleaning-up-process also includes working up the material that has collected in the last three or four years for your 'Pteris story.' I have finished this during these last days, and I hope to have cleared up this matter now as far as three species of ferns are concerned. Your side is thoroughly correct. It turns out — when compared exactly — to be a very instructive special case of a common phenomenon. With this I have come to answering your letters, for yours of last October starts with Pteris. As for the complaints which you add to your remarks, I can answer only with the wish that you may not take to heart what the American botanophiles and mycophiles say about you and Cooke. If you continue in the same way as in the last papers you sent me, these gentlemen will certainly come to reason, if not all, then at least many of them. It's not different with me: Berkeley and his set always consider my kind as very wretched fellows, and still, by now, all intelligent people know what they should think of it. The only way to achieve something, is not to let yourself be bewildered. I had a lot more trouble with Hallier, Sollman, Hoffman etc. than anybody has nowadays.

To continue with your mycological questions — I see in Fischer von Waldheim's new survey of the Ustilaginales that he indicates Urocystis colchici on

several monocotyledons, also on Allium (A. rotundum). On another Allium, A. magicum, he indicates another Urocystis species, U. magica. This is about all that is known about Urocystis on Allium. Considering the great similarity of the spore characters of most of the species a decision on the identity of species seems to be very difficult to me. Why are not all species of Urocystis, or all species on monocotyledons, a single species? I shall send your fungus to Fischer, so he can compare it with his materials. But I shall wait till winter because he is probably absent from Warsaw now . . .

You know all that's important about Rostafinski, that is that he is in Krakov, very industrious, and with good success. I would not know much more myself without going into details. As for Stahl, you probably don't know that he is privatdocent in Würzburg. He went there in the summer, and is very satisfied with everything thus far. I talked with him recently in Strasbourg, and I hope he will also write me.

You do not have to fear that Gilkinet has forgotten you even if he should not have written to you in the meantime. I can tell you so with certainty, for we talked about you very much when I visited him last April in Lüttich. Here in Strasbourg we had the same experience with him as you had — not a word from him. In April I had a chance to go to the Horticulture Exposition in Amsterdam, and I took advantage of this trip to visit him in Lüttich. After a very friendly reception, I soon found out the good reason for his personal and botanical silence — he has accepted the position of chargé de cours at the University, that is to say for pharmaceutical chemistry. He has to manage a chemical laboratory and, at least for a long time, he was entirely absorbed by the necessity of remodeling himself for work in this new job. This is understandable and it will justify him also in regard to you . . .

There is not much to say about Solms except that he is as you know him — short active semesters, alternating with long vacation trips. Last fall he was in Moscow and Stockholm, at Easter in Athens. Otherwise there were many changes in this laboratory. Dr. Wilhelm, whom you knew, is the only stable man. This summer it was very lonely, since, because of illness and other reasons, only two people were working. I shall send you some dissertations which were made during the last year . . .

In order to achieve a symmetrical conclusion to this letter, I shall talk subjectively again. In my house, everyone is rather well, and so am I, especially the last four to six weeks. I accompanied my family to Switzerland yesterday — they are in Interlaken again. I left them for a week to go here, and then to Bex (Rhône Valley) to the Swiss Meeting of Natural Scientists, and then to Interlaken, too. In mid-September we shall be at home again.

Goodby for this time, best regards from my family and myself, and do not punish me by too long a silence.

Sincerely yours

A. De Bary

HARVARD UNIVERSITY
CAMBRIDGE, MASSACHUSETTS

2(1): 39–51 FARLOWIA January, 1945

NOTES ON FARLOW'S AGARICALES FROM CHOCORUA

ROLF SINGER [1]

To those who are acquainted with the White Mountains of New Hampshire, the name Chocorua brings to mind the beautiful lake in which is reflected picturesque Mount Chocorua, but few realize that the region is a mycologist's paradise. In this region of beeches, birches, maples, oaks, pines and hemlock at the lower elevations and of spruce and balsam below the nearly bald granitic summit of the mountain, there are habitats of widely varied types and ecological conditions that make possible the occurrence of many different species of fungi.

Whether it was beauty of the scenery, the presence of congenial faculty colleagues, or the presence of these varied and excellent collecting grounds or some other factor that caused Dr. Farlow to choose Chocorua as his summer home it is impossible to say. However, it is obvious from the large number of fungi in his herbarium which were collected in this region, that when he left his office on the top floor of the Botanical Museum in Cambridge where his herbarium was at that time maintained, he lost few opportunities for going out into the woods of Chocorua and vicinity to make collections of fungi, many of which he sent to his colleagues who were interested in special groups. Among these colleagues was his friend and former student, Dr. E. A. Burt, who cites many of Farlow's Chocorua specimens in his monographic studies of the Thelephoraceae and who in 1909 wrote to Farlow that he was turning up many unusual and interesting species of *Hypochnus* (i.e. *Tomentella*) in that region. While he was making these miscellaneous collections, he also had in mind the eventual publication of an illustrated agaric or mushroom flora and it was at Chocorua that Joseph Bridgham and L. C. C. Krieger, under his critical supervision, executed in water color and at natural size a large number of exquisite illustrations, a small number of which have now appeared in the "Icones Farlowianae." The larger proportion of the paintings that remain unpublished, and unfortunately not available except to those mycologists who come to the Farlow Herbarium to study specimens and plates, nevertheless are extremely valuable as permanent records of the fungi as they appeared when freshly collected. They are also of value because they illustrate species which, although Farlow collected and determined many of them, were in many instances seen and verified by Charles Peck of the State Museum at Albany, the foremost American agaricologist of the period, as well as by European specialists in the group. Thus Chocorua was the source of a large number of specimens, not only for Dr. Farlow but to many colleagues with whom they were shared, as well as for those who

[1] The writer is indebted to Dr. David H. Linder for the introduction to this article.

were fortunate enough to be guests at his summer home and do their own collecting. However, despite the sharing of specimens and his efforts to have identified accurately all those fungi that were illustrated by his artists, there nevertheless remain many that are still to be identified. Also, there are others which, although named as accurately as the knowledge of the time permitted, are worthy of additional notes. A few of these are discussed in the following paragraphs.

I. SUILLUS GRANULATUS IN NORTH AMERICA AND EUROPE

One of the common species observed near Chocorua is a bolete generally determined as *Boletus granulatus* L., and under this name illustrated and described in the *Icones Farlowianae*(3). This species, described by Linnaeus and Fries from Sweden, has previously been studied by the author in Europe. It was, therefore, interesting for him to compare his notes with data gathered on abundant living material at Chocorua. We shall at this point anticipate our eventual conclusion, and stating that the American form actually differs macroscopically, microscopically, and ecologically from the European type, name it **Suillus** [2] **granulatus** ssp. **Snellii** [3] Sing. ssp. nov.

Suillus granulatus ssp. **Snellii** ssp. nov.

Notis macroscopicis subspeciem *leptopodem* fortiter revocantibus in mentem; notis chemicis haud notabilibus in comparatione cum typo; sporis minoribus (6.8–8.2 x 3 μ) a subspeciebus ceteris recedens; habitatio: cum *Pinibus strobis* (rarissime cum aliis coniferis) ad terram plerumque arenosam gregatim in America boreali; collectio typica in Farlow Herbarium conservata atque a D. H. Linder & R. Singer prope Chocorua, N. H. collecta est.

Macroscopical characters: There is no need of wasting space by redescribing *S. granulatus* ssp. *Snellii* macroscopically. The reader will find good descriptions of it in most American books and papers dealing with boletes, e.g. in "Icones Farlowianae," Atkinson, and others. We may only add that the spore print is "Isabella color." [4]

Microscopical characters: Spores pale yellowish or pale melleous, thin-walled ellipsoid-subfusiform, frequently attenuate toward the upper end and usually with a subhilar depression, 6.8–8.2 x 3–(3.5) μ; *basidia* clavate, 4-spored, hyaline, but at some spots covered with brownish resinous masses emanating from the cystidia, 20–24 x 6–7 μ; *cystidia* frequent, extremely crowded on the pores where their excretions or incrustations cover large portions of the hymenium, honey color or hyaline when seen without the incrustation (after crushing the preparation in an alkaline

[2] Since it has been proved by D. P. Rogers that S. F. Gray's "Natural Arrangement" is post-Friesian, the author thinks that Snell's (12) proposal of the name *Suillus* instead of *Ixocomus* is justified.

[3] W. H. Snell was the first accurately and reliably to indicate one of the main characters which separate the American subspecies, i.e. the small spore size; we therefore feel that it is most appropriate to dedicate this subspecies to him.

[4] All colors cited in quotation marks are those of Ridgway unless indicated otherwise.

medium), thin-walled, smooth, clavate-fusoid, more rarely claviform or fusiform, or ampullaceous, or subcapitate, or a combination of these, 34–38 x 6–10.5 μ; *trama* of the tube walls divergent and with a distinct regular mediostratum; *cuticle* with a distinct ixotrichoderm, some of the hyphae somewhat incrusted; *hyphae* of the context hyaline, thin-walled, consistently without clamp connections; *glands* consisting of masses of strongly incrusted and pigmented or rarely hyaline dermatocystidia similar to the ones observed on the pore mouths, but more variable in size.

Chemical characters: **KOH** on the surface of the pileus: lilac, becoming grayish brown in a few seconds, young stages more intensely and persistently lilac; on the context of the pileus: lilac, becoming grayish brown, young stages usually not showing any reaction except where the context is showing the first yellowish spots (near the tubes); on the pores and tubes: almost black immediately. — **NH_3** (prolonged action) and **NH_4OH** on the surface of the pileus: slowly lilaceous brown, in young stages slowly gray or grayish brown; on the context of the pileus: lilac (except for young stages with no appreciable reaction); on the pores and tubes: lilac (except for young stages with no appreciable reaction).

Habitat: On the ground in coniferous and mixed woods, in mycorrhizal connection with *Pinus strobus* and *P. monticola*, rarely, near stands of these pines, transgressing into pine-free stands of hemlock (*Tsuga*) or fir (*Abies*). Fruiting from June to November.

Distribution: The distribution of this subspecies has not been established satisfactorily because of the fact that many species have been wrongly determined as "*Boletus granulatus*" in the past. The geographic area of ssp. *Snellii* most probably coincides with that of the five-needle pines with which it is associated.

COMPARISON WITH CLOSELY RELATED SUBSPECIES AND SPECIES OF *SUILLUS*

1. **Suillus granulatus** (L. ex Fr.) Snell ssp. **typicus.** In the American form the context, tubes and the stipe remain white or pallid for a longer period than in ssp. *typicus*; the color of the pileus and the glands of the stipe reach darker tones than in the latter. In our specimens from Chocorua as well as from Massachusetts and New York, the color of the well-pigmented pilei was about "orange cinnamon," sometimes near "cinnamon rufous," or darker than these, and then reaching almost all shades familiar in *Suillus luteus* (L. ex Fr.) S. F. Gray, but pale or bleached forms are not uncommon, the bleaching starting mostly in the center of the pileus; the glands tend to become purple or blackish long before such a change is seen in the European form. There are, however, cases where the glands remain rather inconspicuous in the American form, and others where they darken early in Europe. The former should be interpreted as transitions toward **Suillus brevipes** (Peck) Sing. comb. nov. (*Boletus brevipes* Peck) while the latter appear to be transitions toward another subspecies of *S. granulatus* which we shall discuss later. The macroscopical difference between the European type and the American form is easy to see

when good colored illustrations of both these forms are compared side by side, though the comparison of dried material does not show striking differences.

The microscopical differences between these two forms are restricted to the spore size. This, however, is the most important distinguishing character. The spores of a specimen collected by Buchholtz in the Mikhailovski Park in the Moscow region were found to be 8.3–9.8 x 3.3–3.5 μ, and other notes on ssp. *typicus* contain similar measurements which, in comparison with ssp. *Snellii*, are decidedly larger. The other microscopical characters do not seem to differ noticeably in these plants.

The chemical characters of the European form are nearly identical with the chemical characters given above for ssp. *Snellii*.

2. **Suillus granulatus** ssp. **leptopus** (Pers.) Sing. comb. nov. (*Boletus circinans* ssp. *leptopus* Pers.) (8). This is the same as the species this author indicated under the name *Ixocomus Bellinii* (Inz.) Maire.[5] Certain features of the American form, ssp. *Snellii*, seem to indicate a close relationship with ssp. *leptopus*. However, the spores of ssp. *leptopus* are not small as in ssp. *Snellii* but large as in ssp. *typicus*. The author found them 8.5–10 x 3.5–4.5 μ, and occasionally reaching 16.7 x 7 μ, and the basidia 27–29.5 x 6.8–9.5 μ in a specimen from Hammam El Cif, Tunisia, collected by Bénier and determined by Patouillard.

3. **Suillus placidus** (Bon.) Sing. comb. nov. (*Boletus placidus* Bon.). This is the same as *Boletus albus* Peck as found abundantly in Massachusetts and New York as well as in Europe by the author. Kallenbach thinks that this is the same as *Boletus Bellinii* or what we call *Suillus granulatus* ssp. *leptopus*. But this confusion merely results from the fact that Kallenbach does not know the latter except from the literature. We have found that though *S. granulatus* ssp. *Snellii* and *S. placidus* often grow associated with one single tree, side by side, there is no difficulty distinguishing these species macroscopically.

The spore size of *S. placidus* is about intermediate between *S. granulatus* ssp. *leptopus* and ssp. *Snellii*. This difference even though slight is constant. It is in accord with European measurements. Snell (11) has also indicated the slightly larger size of the spores of *S. placidus* when compared with the American form of *S. granulatus*.

While thus the microscopical difference between *S. granulatus* ssp. *leptopus* and *S. placidus* is very slight, the chemical characters which are about the same in all subspecies of *S. granulatus* including ssp. *leptopus*, tend to separate the latter from *S. placidus*. The ammonia reaction tends more towards red tones in adult specimens of *S. placidus* than in *S. granulatus sensu lato*. It is remarkable (and should be kept in mind when the usefulness of chemical reactions in boletes is discussed) how constant these reactions are if specimens of corresponding stages are compared. In the

[5] Revue de Mycologie **3:** 48. 1938. "Et si nous preferons de le classifier comme variété de ce dernier (*I. granulatus*), nous pouvons reprendre le nom de Persoon." Konrad (6) considered it as a subspecies of *S. placidus*; Gilbert (4), as an independent species.

writer's paper cited above (9), this same reddish reaction was indicated from specimens growing on *Pinus cembra* on granite soil in Europe, and later was checked on specimens growing under *Pinus strobus* on sandy soil in the Adirondack Mts. of New York, U. S. A. The results were identical. In order to give the reader the full descriptive facts as drawn from American material of *S. placidus* for comparison with *S. granulatus*, American form, we cite our notes on the chemical characters of the former species:

KOH on the surface of the pileus: lilac to violet, after a while becoming deep reddish brown to chocolate, in young stages occasionally salmoneous or purplish salmoneous at first, lilac or violet after a while; on the context of the pileus: lilac to violet, strongest on the yellowish colored places in very old specimens, and only on these places (if there are any) in younger material; on pores and tubes: reddish brown in adult specimens, but no reaction or else a slow change to pale sordid brown in young stages. **NH_3** on the surface of the pileus: lilac to violet; same reaction on the context, but none when young; on pores and tubes: *initially salmon color to reddish tan*, but no reaction when young. **NH_4OH** on surface of the pileus: stronger and deeper than with NH_3; on context of the pileus: same reaction as with NH_3; on pores and tubes: blue to gray, but no reaction on young stages; in the very old yellow stage the tubes reach "*zinc orange*" (R.) with NH_3-vapors, and the surface of the pileus becomes *brownish-red*, the context of the pileus *salmon color* under their influence.

The above data prove that Kallenbach's opinion (5) is erroneous. Kallenbach thinks that he can divide *S. placidus* into four "formae": 1. f. *Pini strobi*; 2. f. *Pini cembrae*; 3 f. *Pini halepensis* (our ssp. *Bellinii*); 4. f. *americana*. As it looks to us, if there are any forms to be distinguished, they should be f. *Pini cembrae* and f. *americana* (in Kallenbach's terminology). The European plant on *P. strobus* is either introduced with the trees, and therefore the same as f. *americana*, or it has originated from the European form on *P. cembra* (which is much less probable), and then it would be the same as f. *Pini cembrae* since there is no evidence of acquired specialization (inability to grow on the old host, *P. cembra*), nor any morphological or chemical differentiation. Kallenbach's f. *Pini halepensis* is not a form of *S. placidus* as shown above. Consequently, all he says about the geographic area of his *S. placidus* is to be understood "cum grano salis." The African and Asiatic localities given refer to *S. granulatus* ssp. *leptopus*. The European ones are almost irreparably mixed up.

MYCORRHIZAL CONNECTIONS OBSERVED IN THE RACES OF *S. GRANULATUS*

The writer has studied the typical European form in Central and Eastern Europe. It has consistently been found in the neighborhood of *Pinus silvestris*, in some cases under *Pinus montana* (in the Alps) and *Pinus uncinata* (in the Pyrenees); it has also been collected under *Pinus austriaca* in the Wiener Wald. This latter location, however, may not be the correct place to look for the typical *S. granulatus*; at least, my notes seem insufficient for definite conclusions when seen in the light of more recent developments.

The Mediterranean form, *S. granulatus* ssp. *leptopus*, was studied by the writer in large numbers on the sand dunes of the Mediterranean Coast near Prat de Llobregat, Catalonia, Spain, in 1934. They were associated with pine, mostly *Pinus pinea*, and were fruiting most plentifully in October. In Africa they reach a maximum in January and February. Other hosts or symbionts are: *Pinus halepensis*, *P. pinaster*, and *P. pithyusa*. In mixed stands of these Mediterranean pines and *Pinus silvestris* some intermediate forms may be observed, thus the soil also may play an important rôle in this. Besides, old specimens of the Mediterranean race often are hard to distinguish from *S. granulatus typicus*.

The American form, in contrast with the European forms, grows with *Pinus strobus*, at least preferably so. The Chocorua specimens, observed by D. H. Linder and the writer, were obviously connected with this five-needle pine, and occurred as well in pure pine stands as in mixed woods with scattered pines. However, some of the fruit bodies were too far from any pines to assume connection between their mycelium and the pine roots. They grew in a *Fagus grandifolia* stand with intermixed *Tsuga canadensis*, and were obviously connected with the latter. They were not otherwise different from the pinophilous majority. In Newcomb Co., N. Y., where the boletes were likewise found to be connected with *Pinus strobus*, a similar ecological anomaly was observed when a form similar to *S. granulatus* in a few rare cases grew far from pines in a very open stand of *Populus tremuloides* and *Salix* spec. with numerous intermixed firs (*Abies balsamea*), and was clearly connected with the latter. But in this case, the fruit bodies seemed to be morphologically modified: they were somewhat larger than the average pinophilous plants and the stipe was pure white as in **Suillus brevipes** (Peck) Sing. comb. nov. (*Boletus brevipes* Peck), and not dotted-glandulose in its lower third to three-quarters, and only minutely granulose in its upper portion; it was rather elongate and slightly attenuate or swollen below; the margin of the pileus was strongly fibrillose-tomentose, probably from a rudimentary veil as occasionally observed in *S. brevipes*; the tubes were strongly decurrent as in a certain form of *S. brevipes*, growing under abnormal ecological conditions (in dense mesophytic hammocks) in Florida (this form was described as *Boletus pseudogranulatus* Murr.); the context showed reddish discoloration. All this points to the conclusion that the American form of *S. granulatus* is not, as the European races probably are, at least when growing spontaneously in nature, confined to very definite soil conditions and to a certain limited number of hosts (two-needle pines only), but able under certain conditions to pass over to other neighboring conifers, either with slight morphological changes (as in New York with *Abies* [6]), or without any such changes (as in Chocorua). In neither case did the soil contain a considerable amount of lime. In the light of recent

[6] At the present stage of my studies, I do not think that it would be wise to insist on the above determination of the specimens concerned. It is also possible that they were not closest to the American form of *S. granulatus*, but rather an extreme form of what Peck called *Boletus albidipes*.

publications it seems probable that the western white pine (*Pinus monticola*) is another symbiont of *S. granulatus* ssp. *Snellii*, a relationship which, considering the taxonomic position of this pine, would not be surprising at all.

As for the ecological characters of *S. placidus* it is well known that this species grows in symbiosis with two five-needle pines, *P. strobus* and *P. cembra*. It thus appears to be closest ecologically to *S. granulatus* ssp. *Snellii*, not ssp. *leptopus*.

Consequently each of the races of *Suillus granulatus* evidently has, in nature, its own requirements as to mycorrhizal hosts. Since these hosts have very definite geographic areas, the fungi concerned have them also. All this corroborates the statement that there are myco-ecological as well as geographic races for which we use the taxonomic term subspecies. *S. placidus*, however, not having a host of its own, yet morphologically and chemically more differentiated than the other forms discussed, must be treated as a separate species. I am aware of the fact that many taxonomists prefer to call forms like ssp. *Snellii* autonomous species rather than subspecies. More detailed information on **Suillus albidipes** (Peck) Sing. comb. nov. (*Boletus albidipes* Peck) will be needed to decide whether in this case we have to deal with a group of small species, or rather with a complex species consisting of several subspecies, possibly including even *S. albidipes* and *S. brevipes*.

II. REDESCRIPTION AND NOTES ON BOLETUS RUBINELLUS PECK

Macroscopical characters: **Pileus** "light Corinthian red," "Corinthian red," "Etruscan red," "deep Corinthian red," and often reaching "Indian red" in the middle, often more brownish tones mixed in when old, or bleaching to a uniform pale yellow, but normally only the margin, if at all, light yellow to yellowish white, warty-floccose, occasionally almost squarrulose-verrucose on the disc, more faintly tomentose on the margin, the flocculae more or less detersible, subviscid when wet, dry in dry weather, the margin sterile (about 0.5–2 mm.), broadly conical or convex, eventually often broadly umbonate, 10–50 mm. broad. — **Tubes** (bluish) pink to salmoneous, or dingy reddish, eventually with a brownish tone, adnate or depressed around the stipe, medium long (about 5 mm.), pores initially daedaleoid, later angular, and rather small to rather wide (up to 1 mm. in diameter), sometimes radially elongate near the stipe. Spore print ferruginous-brown. — **Stipe** subconcolorous, often mixed with yellow or yellowish white, subglabrous to slightly pustulate-subflocculose, dry or almost so, smooth or almost so, equal or slightly enlarged near the base or with widened apex, solid, 10–50 x 2–10 mm. — **Context** whitish yellow to brownish yellow, usually more intensely colored in the stipe, or near the base with some pink portions in some specimens; odor none; taste mild. — **Habitat:** On the ground in woods, always under conifers. July to September. Mostly gregarious. Infrequent to locally moderately frequent.

Microscopical characters: **Spores** 9.5–13.8 x 3–4.2 μ, long ellipsoid, some

more fusoid, smooth, thin-walled, brownish to melleous, rather pale; **basidia** 25–32 x 8–10.5 μ, 4-spored; **cystidia** usually ampullaceous or fusoid with a bottleneck-shaped apex, but also subulate or fusiform without an elongate apex, 38–52 x 7–10 μ, the "bottleneck" if present about 3–3.8 μ thick, hyaline or more rarely brown, not as conspicuously incrusted as in *S. piperatus*,[7] rather numerous and occurring on the pores as well as in the tubes; **trama** of the tubes well differentiated in a completely hyaline, more gelatinized and consequently somewhat loosely arranged and slightly but distinctly divergent lateral stratum, and a slightly colored, denser, regular mediostratum, though in mature specimens this differentiation becoming more and more indistinct, and the hyphae more and more parallel, without clamps, but with occasional nodules or bridge-like connections between parallel hyphae; **warts** of the covering layer consisting of long, cylindric, hyaline, thin (1.5–8 μ in diameter) hyphae with thin walls and without clamp connections, their wall more or less gelatinized and imbedded in a gelatinous mass, their free ends obtuse, and sometimes with strange protuberances.

Chemical characters: **KOH** on the surface of the pileus: blackish, then becoming brown, eventually brown-red; on pores and tubes: dirty brown; on context: tawny brown. — **NH_4OH** on the surface of the pileus: yellow, then becoming olive yellow; on the pores and tubes: deeper pink, eventually gray. — **Aniline oil** on the surface of the pileus: characteristically rapidly deep grayish purple. — **Formol:** no reaction.

The above description has been drawn from collections made by D. H. Linder and R. Singer near Chocorua, N. H., and additional fresh material collected by the writer near Newcomb, N. Y. This material has been compared with the type at Albany which macro- and microscopically proved to be identical. The type of *Boletus Vanderbiltianus* Murr., collected in North Carolina and preserved at the New York Botanical Garden, is the same species. It is said to grow in thin oak woods, but Dr. H. D. House who collected it there remembers that there were conifers scattered in the woods (oral communication). On the other hand, Coker and Beers (*2*), describe and figure (p. 38, *pl. 3, fig. 2–3*, and *pl. 62, fig. 13–14*) this species in a way suggesting that some other species must have been mistaken for *Boletus rubinellus*. This opinion is in accordance with the fact that these authors do not recognize *Boletus Vanderbiltianus* as a synonym of *B. rubinellus*, but say, instead, that they have not collected the former. Furthermore, in a note concerning their conception of *Boletus rubinellus*, they suggest that it "may be only a form" of *Suillus piperatus*. This is probably correct as far as *B. rubinellus* sensu Coker & Beers is concerned, but in our opinion their species is the same as **Suillus piperatus** var. **amarellus** (Quél.) Sing. comb. nov. (*Boletus amarellus* Quél., *Boletus Pierrhuguesii* Boudier, *Boletus rubrotubifer* Kauffm.), a species which I collected in fresh condi-

[7] **Suillus piperatus** (Bull. ex Fr.) Sing. comb. nov. (*Boletus piperatus* Bull. ex Fr., *Ixocomus piperatus* Quél., *Chalciporus piperatus* Bat.)

tion in the Pyrenees, and which is mild and also has the other characters of the North Carolina fungus. The true *B. rubinellus* is a northern species, more frequent in the Adirondacks and the White Mountains, reaching Kentucky in the West, and the mountains of North Carolina and Tennessee in the South. It does not occur in Europe. As for its affinities, the gelatinized surface hyphae and the color of the tubes and spores, as well as its habitat near conifers suggest a close affinity with the section *Piperati* of the genus *Suillus* (*Ixocomus* sec. *Piperati* Sing. 1938, genus *Chalciporus* Bat. 1908). This relationship is confirmed by the anatomy of the tube walls which is quite typical for a *Suillus*. The chemical reactions also agree with those indicated by Singer (9) for this group. Consequently, the new combination **Suillus rubinellus** (Peck) Sing. is proposed.

III. ON LACTARIUS NIGROVIOLASCENS ATK. EX BURL.

Macroscopical description: **Pileus** dark brownish gray or dark grayish brown to almost black, opaque, pruinate-tomentose to strongly velutinous, dry, smooth, convex, eventually depressed, but usually only in the center, and, at the same time, showing a small but distinct papilla, especially when young, 33–73 mm. broad; the margin frequently short-sulcate or coarsely crenate as in many Leucopaxilli. — **Lamellae** light ochraceous yellow, arcuate sickle-shaped, rather narrow: 3–4 mm. broad, acute in front and behind, not anastomosing, moderately close to subdistant, polydymous, simple, decurrent or adnate but from the point of attachment down the apex of the stipe proliferating into very short and low parallel ribs. Color of the spore print on white paper yellow, "F" (Crawshay). — **Stipe** concolorous, whitish at the extreme base which is buried in moss, versiform but usually subequal or equal with only the extreme base tapering downward, faintly tomentose-velutinous, solid, 50–75 x 7–15 mm. — **Context** white, becoming dark violet when wounded. Latex white, showing dark violet spots when exposed to the air in contact with the context. Odor not significant. Taste mild. — **Habitat:** Coniferous wood or mixed wood under conifers, on moss or sometimes on naked soil.

Microscopical description: **Spores** 8–13–(15) x 7–11.5–(13) μ, subglobose, with conspicuous 1.5–2 μ high ridges forming an ornamentation of the type II or IIIa, more or less asymmetric; in authentic print from N. Y., 10.5–11.7 x 8.5–10.5 μ with a moderately dense to rather loosely arranged ornamentation of type II to IIIa (as above), or IIIb, more rarely IV or V, the spines and ridges usually connected by an extremely faint network which is easily overlooked, 1.3–2.3 μ high; **basidia** 27–46 x 9–13 μ, 4-spored, but very few 2-spored ones intermixed; **cystidia** none; **cheilocystidia** on the heteromorphous edge of the lamellae versiform (cylindric, clavate-balloon-shaped, fusoid, or basidiomorphous), hyaline, 14–52 x 3.3–8 μ; **cuticle** of the type called Virescens-type in *Russula*, consisting of a subcutis of globose cells (about 17–20 x 15–17 μ) which mostly proliferate into a subulate, more rarely clavate or cylindrical hair with narrowed or broadly rounded apex and 0–2 septa (not counting the wall between the

subcuticular cells and the hair); these hairs, 20–120 x 6.5–9 μ, are strictly erect and form the epicutis; pigment grayish brown, dissolved in the cell-sap; all hyphae without clamp connections.

OBSERVATIONS ON THE ANATOMY OF THE CUTICLE, THE SPORE WALL AND THE HISTORY OF THE SPECIES

The above description shows that this interesting and rare species belongs in the section *Plinthogali* Burl., because of the structure of the surface and the combination of the macroscopical characters. The structure of the cuticle, strongly reminiscent of what is known as Virescens-structure in the genus *Russula*, has never been described correctly in any species of *Lactarius* where it is characteristic for the whole section *Plinthogali*. We have observed this structure in *L. fuligineus*, *L. azonites*, *L. lignyotus*, *L. acer*, *L. nigroviolascens*, a southern species with unchanging latex, and a new Florida species with yellow watery latex. Unfortunately, Neuhoff in his work on the "Milchlinge" (7), misinterpreted the structure of the *Plinthogali* by taking the cellular subcutis for the outer layer, and the hairs for the inner layer. Nothing like this, however, can be observed in any European or American *Lactarius*. The spores of *L. nigroviolascens*, as described above, seemed to be more cristulate than the description given by G. S. Burlingham (1) would indicate. However, Miss Burlingham was kind enough to send me some authentic material, probably from the type locality, or not far away from it, consisting of a good spore print obtained from a specimen that she herself collected near Ithaca, N. Y. If the extremely faint connecting veins found here between the warts and ridges are not taken in consideration, at least a minority of spores of this print shows about the same marks as two of the three spores figured (l. c., fig. 3^2). It must, therefore, be admitted that the ornamentation of the spores of *L. nigroviolascens* Atk. ex Burl. varies to a certain amount not only in different collections but also occasionally in a single print. The uniformly cristulate spores were observed in all our New Hampshire material. Farlow had it from Chocorua, Shelburne, and other places in New Hampshire, and his collections remained partly undetermined, or were tentatively determined as *L. lignyotus* Fr., a closely related but different species, easily distinguishable by the pink to latericious color of the wounds. Fresh material in excellent condition was collected by D. H. Linder and R. Singer in the same region where Farlow collected this species for the first time, i.e. in 1891, and 1910. Farlow had the essential data on this species, and gave correct notes with the specimens, indicating how it differs from similar Lactarii. Though realizing it was different from all species known to him, he did not describe it as a new species. At that time, many mycologists would have described a species on far less evidence than Farlow had, but Farlow was much more conscientious in this regard. Incidentally, Atkinson, who collected his specimens many years after Farlow, did not describe them either, but gave them the herbarium name *Lactarius nigroviolascens* which was later (1932) validly published by Miss Burlingham.

IV. A NEW SPECIES OF RHODOPHYLLUS: R. FARLOWII

COLOR PLATE

Rhodophyllus Farlowii Sing. spec. nov.

Pileo laete aurantiaco-luteo, non fortiter hygrophano, convexo, umbilicato, ad marginem pellucide striato, levi, glabro, haud viscido, 24–40 mm. lato; lamellis salmoneis vel pallide salmoneo-latericiis, subangustis vel moderate latis, adnatis vel dente decurrentibus, confertis vel subconfertis; stipite concolori pallidioreve, glabro, levi, sicco, cavo vel farcto-subcavo vel solido, aequali vel ad apicem subattenuato, 50–76 x 2–6 mm.; carne alba vel subconcolori in adultis, inodora; habitatio ad ligna et humum in silvis montanis et in paludosis, aestate.

Pileus rich orange-yellow, more yellow between the deeper orange striae, tending to bleach from the center outward, and somewhat hygrophanous, convex with a distinct broad umbilicus, the margin transparently striate about halfway to the center, smooth, glabrous, not viscid, 21–40 mm. in diameter. — **Lamellae** salmon-pink to salmon-pale-lateritious, 2.5–5 mm. broad, broadest in the middle or in the inner third, adnate with decurrent tooth or subdecurrent to decurrent, close or subclose. Spore print pink. — **Stipe** concolorous with the pileus, or slightly paler, the base more whitish, glabrous, smooth, dry, hollow or solid, or stuffed-subcavous, equal or slightly tapering upward, 50–76 x 2–6 mm., usually about 4 mm. broad at the base, and 2–3 mm. at the apex. — **Context** white, at times somewhat concolorous when old. **Odor** insignificant. — **Habitat:** On wood or on humus in mountain forests and swamps, under **Tsuga** and other trees in mixed stands. July and August.

Microscopical description: Spores 7–10 x 5.2–6.3 μ, pale pink, approximately hexagonal and the shape of a benzine ring when seen frontally, or the sides odulose and the spores thus becoming symmetrical-complex, their hilar portion forming an angle of about 90° when seen frontally; basidia about 50 x 14 μ; cystidia not seen.

This beautiful species is easily mistaken for a *Hygrocybe* (Hygrophoraceae) because of its color and habit. It has been found by D. H. Linder and the writer in July, 1941, near Chocorua, N. H., and was compared with dry material preserved at the Farlow Herbarium, collected by W. G. Farlow himself near Chocorua in August 1906 ("Kr. 229"). Another collection was made by Davis at Stow, Mass. ("Kr. 280"). Both were painted by L. C. C. Krieger and are unmistakably the species described above as the northern form. Then, in 1942, the writer twice collected what seems to be the same species in Highlands Hammock State Park in Florida. These southern specimens are sometimes of a pure yellow rather than orange, and the pileus is perhaps somewhat smaller. Though these differences are slight and not striking, and the microscopical characters are the same, it seems wiser to describe them separately.

Pileus "light orange yellow" to "deep chrome," or more yellow without an orange tinge: "light cadmium" with the margin "mustard yellow,"

eventually much more sordid and bleached: "honey color," margin "cartridge buff," hygrophanous, but not very strongly so, transparently striate on the margin, convex with narrowly depressed disk, later infundibuliform, smooth, glabrous, not viscid, 13–22 mm. in diameter. — **Lamellae** "pale orange yellow" or (in the yellow specimens) "maize yellow," bleaching to "cartridge buff" or more pinkish from the spores when old, horizontal, decurrent, rather narrow, subclose. — **Stipe** subconcolorous with the pileus or "lemon chrome" at the apex and gradually paler downward, the base pallid or whitish, glabrous, smooth, not viscid, subequal, 40–55 x 2–3 mm. Mycelium white. — **Context** whitish or somewhat concolorous. **Odor** insignificant. — **Habitat:** On the forest soil in low hammock, especially where the broad leaved trees are intermixed with *Pinus palustris*. September. Infrequent.

Farlow did not make an attempt to determine this species, and even the determination of the genus was very difficult at the time. Thus, one collection was called "*Eccilia* or *Clitopilus*" while the other was marked "*Leptonia* spec. vel. *Entoloma*," and this in spite of the fact that Farlow was aware of the specific identity of the collections mentioned. This proves once more how ridiculous the argument is that Fries's classification, though not natural, allegedly has the advantage of being very practical for determination. Here we have the example that a man of the skill of Farlow put two collections of the same species tentatively in four different genera. In the modern scheme used by Romagnési (*in litt.*) and the writer (10), *Rhodophyllus Farlowii* is easily determined as belonging in the subgenus *Leptonia* Fr. *sensu* Romagnési & Sing. In color, this new species comes close to *R. salmoneus* (Peck) Sing. which likewise occurs around Chocorua. Microscopically, however, and also as far as the shape of the pileus is concerned, the new species belongs in a different taxonomic group. Two colored plates, executed by Krieger, and illustrating the specimens from Chocorua and Stow, are preserved at the Farlow Herbarium, and so are the specimens from these collections. The type collection is the one collected in 1941, and this is also preserved at the Farlow Herbarium.

This may be a fitting occasion to recommend the genus *Rhodophyllus* Quél. as a nomen conservandum to the next International Congress dealing with the problems of fungus nomenclature. Not only is this name used by those authors who have proved, by adding valuable new information on the genus (Kühner, Lange, Romagnési), that they are competent specialists, but it also would be historically just to use the name given by the author who first discovered that the Friesian subgenera and Saccardo's genera *Entoloma*, *Clitopilus* (excluding the *C. prunulus*-group), *Leptonia*, *Nolanea*, *Eccilia* and *Claudopus* (excluding the *C. variabilis*-group), are all congeneric. However, the most important reason for recommending that *Rhodophyllus* be conserved is that if the rules are to be followed literally in this case, one of the just mentioned Friesian subgenera must be emended and all the Rhodophylli would become either *Entoloma*, or *Nolanea*, or *Eccilia*, etc. In this case, whatever the "legally" chosen genus may be, the

number of new combinations necessary to transfer the species listed by Fries and his followers in one of the remaining genera, plus the species recently described in *Rhodophyllus* only, would be much higher than the number of new combinations still necessary in order to transfer the species not yet transferred to *Rhodophyllus* (such as a number of American species properly belonging in this latter genus in case of its conservation). This statement may or may not be true if only the number of species and so-called species in Saccardo's "Sylloge Fungorum" are compared, but it is overwhelmingly true if the number of important, widely distributed and valid specific names is taken as a base for comparison. If this question is not taken care of soon, it is to be feared that some McGinty *redivivus* will turn out a hundred new combinations a day, making *Entoloma rhodopolium* an *Eccilia*, or *Claudopus byssisedus* an *Entoloma*, or *Rhodophyllus Farlowii* a *Claudopus*, depending on which combination of names appeals to him at the time. The scores of resulting synonyms will have to be carried along for centuries.

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LITERATURE CITED

(1) **Burlingham, G. S.** Two new species of Lactaria. Mycologia **24** (5): 460–463. 1932.
(2) **Coker, W. C., and A. H. Beers.** The Boletaceae of North Carolina. Chapel Hill. 1943.
(3) **Farlow, W. G.** Icones Farlowianae. Cambridge. 1929.
(4) **Gilbert, E. J.** Les Bolets. Paris. 1931.
(5) **Kallenbach, F.** Die Pilze Mitteleuropas **I.** Die Röhrlinge. Leipzig. 1926–38.
(6) **Konrad, P.** Notes critiques sur quelques champignons du Jura. Troisième série. Bull. Soc. Myc. Fr. **43** (2): 145–204. 1927.
(7) **Neuhoff, W.** *in* Die Pilze Mitteleuropas **II** (b) Die Milchlinge. Leipzig 1935–[39].
(8) **Persoon, C. H.** Mycologia Europaea **II.** Erlangen. 1825.
(9) **Singer, R.** Sur les genres Ixocomus, Boletinus, Phylloporus, Gyrodon et Gomphidius. Rev. Myc. **3:** 36–53, 157–177. Pl. IV. 1938.
(10) ———. Type studies on Agarics. Lloydia **5:** 91–135. 1942.
(11) **Snell, W. H.** Notes on Boletes II and VI. Mycologia **25** (3): 221–232. 1933 and Mycologia **33** (1): 23–37. 1941. (The latter in collaboration with E. A. Dick).
(12) ———. New proposals relating to the genera of the Boletaceae. Mycologia **34** (4): 403–411. 1942.

2(1): 53–70 FARLOWIA January, 1945

WILLIAM GILSON FARLOW
PROMOTER OF PHYCOLOGICAL RESEARCH IN AMERICA
1844–1919

Wm. Randolph Taylor

It is not often that an American botanist has deeply influenced two diverse fields of his subject, but William Gilson Farlow is recognized as a dominant figure both in the study of algae and of fungi. His active career started just as the subject of Botany in this country began to be divided into specialties, and men began to concentrate their attention somewhat on a particular field, thus following the example of the Europeans. Farlow was not without the knowledge of general field botany appropriate to his day, but he both in teaching and research was a specialist in cryptogamic botany. He exercised a profound influence in this field. The algae were his first enthusiasm; he never lost his liking for them and it is the purpose of this sketch to outline the development of his prestige among phycologists, and to try to see how he influenced the study in this country. It is not proposed to attempt to give a general biographical account; that has been well done by others, particularly Setchell.

Farlow seems to have gone through his college career with some definiteness of purpose. Biographical sketches by his students and associates indicate that his scientific taste exhibited itself in the active pursuit of botany during his undergraduate days, though this was balanced by a marked skill in music. Probably there was little formal instruction available to him in his future field, although what the academic customs of the day denied the infectious enthusiasm of his teacher, Professor Asa Gray, no doubt supplied. The career of a professional botanist doubtless looked like a rather barren prospect to his parents; he with his keen mind for business affairs no doubt had a fair estimate of it. He pursued what we today would consider an essentially classical training and followed the academic term with two years at Harvard Medical School, where he did exceedingly well. Thereby he equipped himself for a remunerative profession; having, thanks to his family's comfortable circumstances, no urgent need for exercising it, he turned to his favorite science of botany and entered Gray's laboratory as his assistant.

For an insight into Farlow's earliest botanical activities we have available little material. In a day when the keeping of diaries was a common custom, he seems to have abstained, and the correspondence of his college days does not seem to have survived. As a result we have nothing before his adult scientific correspondence to tell us when he became especially interested in algae, though of later scientific correspondence there is an abundance.

We do know that when Farlow joined Gray's Cambridge group he did so not to follow in his steps as a vascular botanist, but specifically to enter the practically vacant field of American cryptogamic botanical training. The study of these plants in this country was the professional concern of almost no one. A very few scattered persons were doing specialists' work on lichens, mosses or hepatics which was excellent, but they did not generally hold positions in institutions of such prominence and facilities that their work could be very widely effective. A man in a leading university, concerning himself with the whole field, and organizing its facilities for general training in this field, was urgently needed. In many of the floras of the day a few cryptogams appeared, but in no group had studies in America begun to give for this country the knowledge equivalent to that available to Europeans. Gray saw this clearly, and he had begun to assemble materials as occasion favored. It seems that he had a small but notable collection of algae, the result in the first instance of his friendship with W. H. Harvey who had held the professorship at Dublin, and J. G. Agardh, who was professor at Lund. With this as an incentive it is not strange that Farlow's first active botanical productivity concerned the algae. While still in his apprenticeship he studied a small collection of Cuban marine algae collected by Charles Wright, and published an account of the Chlorophyceae among them in 1871. This, his earliest botanical essay, quaintly illustrated with negative line-cuts on a black ground, shows his painstaking care. He was not yet familiar with the European literature necessary to make this a critical work, but it does show skill and care. It is representative of a type of research which will appear frequently during his career, the report on materials for some exploring expedition.

Meanwhile, his major research work on marine algae was developing. Farlow had joined a group of biologists who spent the summer of 1871 at Woods Hole, Massachusetts, laying the foundation for a biological survey of the area. The United States Commissioner of Fisheries was looking toward the establishment of a research center and hatchery somewhere along the coast, and Commissioner Spencer F. Baird over several seasons examined intensively the advantages of several sites which had been suggested along the New England coast. A small laboratory was set up on the Lightship Service wharf on Little Harbor. Just what share the botanical part of this survey played in the unfolding plans of the Bureau is not clear. In Farlow's own development it confirmed his interest in the New England coast flora. Knowledge of these plants in this country, such as it was, lay with Professor D. C. Eaton of Yale University. He published very little on algae, but did have at New Haven a small collection of New England material, and some additional material from abroad secured by exchange. The friendly connection between these two students of Gray was very useful. Even at first no doubt it greatly fortified Farlow's beginning algal interests; later under pressure of his work on ferns, Eaton gave over the algal field entirely into Farlow's hands. The first fruits of Farlow's interest in New

England algae was a short note (1872) on the algae of the Atlantic Coast, indicating the general character of the flora and some of the striking species.

By now, twenty years after its appearance, the inadequacy of Harvey's *Nereis Boreali-Americana* was evident. Excellently prepared though they were, and for the times accurate, his three volumes had quite too little field work behind them. The months of his too brief visit, with considerable demands on his time apart from collecting of marine algae, were too short to obtain an idea of the algae of the long American coastlines and so he relied on the collections submitted by a few amateurs to complete his catalogue. Local botanists everywhere soon found that Harvey had inadequately presented the algal vegetation of their particular coast, and there began to appear lists aimed at amplifying the record. However, knowledge of marine algae in America was as yet too ill-advanced to permit these lists in general to be taxonomically accurate. They did signalize the general desire for a more complete account of these plants. Farlow, sharing this desire for more complete studies, brought together his observations in a list published in 1873. This is the true start toward his major algal work. Based especially on his 1871 collections at Woods Hole, but including Olney's Rhode Island algae collected in 1846–48, of which those of 1846 and 1847 had been checked by Harvey, and also 1870–71 materials from Greenport and Orient L. I., this paper also contained records which Eaton contributed of plants from New Haven and Watch Hill, and a Miss Pease from Edgartown and Vineyard Haven. This gave Farlow a very respectable list of 103 plants, with eight others considered rare or new to America. It is a matter of interest that Farlow visited and collected intensively at Woods Hole localities recognizable and productive today, over seventy years later. He made this more than a list; though not giving much of descriptive morphological data regarding the various species, he analyzed the flora in relation to other shores, recognized its peculiarities and the importance of Cape Cod as on the line dividing the northern and southern North Atlantic floras.

The publication of this paper was delayed a year and meanwhile Farlow had gone abroad on the first of his notable visits to European institutions. He went with a considerable lot of algae in hand for comparison. His chief base for the taxonomic study of marine algae in Sweden was at Lund, where C. A., succeeded by J. G. Agardh had developed resources for the study of marine algae unapproached elsewhere. Hospitably received there, he firmly established himself in the good graces of Professor Agardh, who through his life gave generous help to Farlow on every occasion. These Agardhian collections are still intact, the specimens numbered in the original sequence, the very large specimens such as *Ecklonia*, *Macrocystis* and *Durvillaea* on great cardboard sheets as Farlow saw and admired them. At Stockholm he was able to accomplish little on his first visit and went on to Uppsala. Here he enjoyed meeting both Fries, the elder at seventy-eight feeble, but assigning Farlow to his son, now the Professor, to be shown the

University. Professor Areschoug, another phycologist, lived nearby, and Farlow noted the excellence of his extensive microscopic preparations of algal structures. He also visited the tomb of Linnaeus at the cathedral, a matter of sentimental duty to all botanists. After about a year with De Bary at Strasbourg, he went to Switzerland where he collected lichens with J. Müller and, in line with his early general botanical training and his notable aesthetic sense, admired hugely the spread of colors which flowering plants developed on the alpine meadows. The developing facilities for botanical research at Geneva impressed him. He contrasted the attitude here with that in Germany where, he writes with scorn, the "Vegetationspunkt mania . . . affects many of the younger botanists to such an extent that they are quite unfitted for practical work." However, he returned to study under De Bary at Strasbourg and there developed such a respect for the morphological approach to a fundamental knowledge of algae that he nearly always insisted that his students develop research from this angle, urging that they reserve the systematics for a time when, by fuller experience, they were more thoroughly equipped. He himself here began a study of *Pteris*, particularly its apogamy, which resulted in the publication of three papers. These papers were not really very important ones in his career, nor did he return afterward to a similar topic for research, but they signalize his conversion to a particular approach in research for younger investigators.

Another most interesting algal contact which he made on this trip was that with J. B. Eduard Bornet in France. Bornet in his collaboration with Gustav Thuret was in a position of great influence in French botanical circles; scientific skill and judgment here combined with financial resources to produce elegantly scientific work of exceptional excellence, and the result was widely acclaimed. Bornet heartily welcomed Farlow and these men became close family friends as well as scientific collaborators. At Bornet's laboratory he was joined by Rostafinski and Janczewski, Polish phycologists who worked chiefly on morphology. Farlow developed the utmost regard for Bornet, and a very extensive correspondence continued throughout their lives, centering chiefly on comparison of specimens. However, the profits from this friendship with Bornet were to develop slowly; the most immediate results from this European trip was to come from his prolonged residence at Strasbourg.

This visit to biological centers in Europe lasted through two years and was followed by other trips during which he firmly established and extended the high regard in which he was held there, resulting, among other advantages, in generous contributions of valuable reference specimens, and exchanges with his herbarium. We cannot follow his tour further, but must consider the later development of his algal interests in America.

He returned from Europe to Harvard, and an appointment which from 1874 was primarily at the Bussey Institution, although he gave instruction in cryptogamic botany at the Botanical Garden in Cambridge, and in 1879 transferred to Cambridge as Professor of Cryptogamic Botany. However,

the brief contact with applied botany at the Bussey Institution induced him to attempt some studies and publication on certain disease-producing fungi, and so began a shift of interest which, though slow to absorb all his research attention, eventually did so.

During this time Farlow worked on the project of a catalogue of American marine algae foreshadowed by his first brief papers. His collections, thanks to his correspondence with Dr. C. L. Anderson and others on the west coast, as well as with all phycologists on the east coast, and his friends abroad, had grown to the extent that he felt accurately informed about these plants. Many specimens had been verified during his conference with Agardh at Lund, and others were sent to him from time to time. In 1873 he published his list of the algae of the south coast of New England, and in 1875 after his return from Europe he expanded this to a list of United States marine algae, adding especially west coast and Florida records, totalling 430 items. This was a list with a short general introduction and a few notes, a less elaborate form of the same appearing the next year under the auspices of the U. S. Fish Commissioner with the addition of notes upon economically useful seaweeds.

A small accumulation, especially of California and Florida algae, was published with a number of new species in 1877, but he never developed this general project further. Instead, he took New England records out of the 1875 list, provided a very useful general introduction, descriptions to the major categories and the species, and in 1881 published his *Marine Algae of New England and the Adjacent Coast*, the work which closed his major algal productivity. This paper well deserved its long career of usefulness; clearly presented and complete for its time, it was the uncontested reference work for its area for over fifty years. His fame as a phycologist chiefly rests on this work.

So much for the general main line of Farlow's algal evolution. What other lines of productivity did he develop? It would seem that we can group them into three classes. First in importance was the exsiccata which he founded and issued with the aid of D. C. Eaton of Yale and C. L. Anderson of California. Second was a group of papers of considerable importance locally, dealing with algal contaminants of Boston's water supplies. Third, a group of minor algal taxonomic papers. Almost all his remaining work falls into one of these three classes.

First we may deal with the *Algae Americanae Boreali Exsiccatae*. This appears in his correspondence but little before it was actually produced. Probably he talked it over with Eaton on some visit, so that little was left for written arrangement. However, Eaton (March 5, 1876) refers to a discussion of label size, perhaps for the exsiccata, and in succeeding letters references to specimens in multiple probably have the same significance, while Eaton (September 8, 1877) refers to ". . . enough for the 30 sets with a few I had already," and a week later refers to ". . . specimens too large for the small fasciculus," after which this work entered considerably

into the interchange. The Eaton correspondence was voluminous, that with Anderson less so. Anderson writes (Sept. 16, 1876) "I like your suggestion in regard to publishing an authentic set of our algae. I shall have considerable time this winter that may be devoted that way. I do not know that I have enough of our species to make a set of fifty but . . ." This seems to open up the business of western participation in the series. The fifth and final issue appeared in July, 1889. The importance of the series lies in the good quality of the specimens, the accuracy of the determinations, and particularly the fact that this first exsiccata of American algae now introduced these plants into many important collections at home and abroad, where before probably only the Harveyan and Agardhian collections had any large representation. It did very much to increase Farlow's prestige abroad. He was largely instrumental in starting the project and in the end it was practically under his full control.

The series of five papers 1876–80 dealing with algae in the reservoirs of the Boston water supply and related topics probably called for little critical research, but they were very important in discharge of Farlow's civic responsibilities. These papers at first dealt with a simple problem of unpleasant taste. Farlow found nothing clear-cut in the algal flora that could be specifically responsible. He indicated a few of the most characteristic freshwater algae present, and was able to assure the public that these algae were in no way dangerous to health. Apparently in at least one 'pond' the trouble was due to a *Spongilla*. Finally in the 1880 paper he wrote a semi-popular treatise on the general features of the algal floras of reservoirs.

Lastly one turns to what may best be described as Farlow's shorter algal works. When one inspects the list it is clear that relatively little bears upon his own collections. Farlow travelled and collected extensively on the west coast, in Florida and in Bermuda. The material went into his collections and presumably was used for exchange, but he published few of the new records which it contained. As papers covering material which he had collected himself, or which at least came from an area and a flora familiar to him, we may recognize his *Notes on New England Algae* in 1882, in 1889 *On Some New and Imperfectly Known Algae of the United States I*, and in 1899, *Three Undescribed Californian Algae*.

The prominent feature of these shorter papers is based upon his commanding position in American botany. While the era of great unspecialized natural history exploration was passing, nevertheless it had not disappeared. Parties were still going off and bringing back heterogeneous, often small, often inexpertly collected lots of material to be parceled out to various specialists for study. As always the algae were a minor part, assembled very clumsily, but they represented a cherished bit of the treasure of the often arduous journey, and they could only be entrusted to Dr. Farlow. So, because he greatly liked these plants and felt it his duty to care for these hard-won little collections, he studied them, occasionally reported new species, and published an annotated list. The geographical range covered is very great, though sometimes there were as few as a half-dozen

species included. His *Cuban Seaweeds* of 1871 was followed by reports on algae from Kerguelen Island in 1876, Cumberland Sound in 1879, Texas and northern Mexico in 1883, Alaska in 1885, Ungava Bay in 1886, South America in 1888, Peary Arctic Expedition in 1895, Azores in 1897 and the Galapagos Islands in 1902.

Farlow's last strictly algal paper appeared in 1916, a very scholarly discussion of the general character and distribution of Pacific Ocean algae, showing that his interest had persisted through the years. His last recorded paper was directly connected with algae too, as it was a biographical sketch of his friend J. B. E. Bornet, published in the same year.

One of the chief circumstances of Farlow's career and one of great potential importance for the development of his phycological interests was his share in the development of the Marine Biological Laboratory at Woods Hole in Massachusetts. The prospectus for this organization was dated 6 April 1887, and Farlow was the Trustee first named in this document. He desired to resign the following year, but letters from Minot and others urged him not to do so, and he served for some years before he severed his connection. During this period of development under the directorship of Professor C. O. Whitman of the University of Chicago, the Trustees were called upon for much financial help. Eventually some came to feel that they were losing control of the finances of the institution, that its expenditures were exceeding what the Trustees should be called upon to bear, and that the limitations which they set upon the activities of the Director were disregarded. Director Whitman clearly had a larger vision than these Trustees, a vision less trammeled by concern over details of economical operation and balanced budget. A group of the Trustees resident near Boston were particularly resentful of the attitude of Whitman and the business management of the Laboratory. Having organized and financed the institution, they felt that they should direct its administration. On the other hand, in the course of ten years the biologists who formed the Corporation, who actually came to work at the Laboratory, now felt that the institution was peculiarly their own, that they could shape, expand, and staff it as they chose, and that the Trustees who were commonly not persons working at the Laboratory during the season, should defer to the general desire of the active group.

The meetings of the Corporation and Trustees had been held in Boston in the winter and most of the Corporation members could not attend; a strong desire for greater participation of the biologists from all over the country led to a demand that meetings be held at Woods Hole during the summer. This was done in 1894, when a meeting of the Trustees was held there, but the Annual Meeting at which the major business was transacted was still held in Boston. The actively dissatisfied group of Trustees, some seven or eight out of twenty-one, engaged in an exchange of bitter letters among themselves, looking toward more effective control of the Laboratory. A special Corporation meeting was called at Boston, 16 Aug. 1897, to pass

by-laws changing the Annual Meeting to Woods Hole, and the date from January to August. This meeting was presided over by Farlow as Acting President; he tried to show that the meeting was illegally called, but failing of support, withdrew. The meeting proceeded under C. G. Kidder to make important changes in the by-laws, improving greatly the scheme of organization. However, seven of the Boston group of Trustees afterward resigned. Six of them, and one other dissatisfied Trustee, attacked the administration of the Laboratory in a very severe article in the journal *Science*, and to this Farlow was a party. The correspondence in Farlow's file shows the stages in the development of this *Science* article, the anger of the participants, and Farlow's share in keeping the text within reasonable bounds. The supporters of the Whitman administration replied in a privately printed pamphlet, subsequent to which, with the withdrawal of the chief dissidents, the whole matter quieted down.

Thus ended Farlow's direct part in what has evolved into the most ambitious project of coöperative biological organization ever attempted. It remains for us to enquire into his share in the work of the Laboratory during his trusteeship, and the persistence of his influence after he resigned. It does not appear that Farlow was ever active in instruction at the Laboratory, or that he was in any large way an investigator there. The first year there was no staff botanist; in 1889 James E. Humphrey was appointed, to be followed the next year by W. A. Setchell. Humphrey had been introduced to the algae by the Rev. J. D. King at the Martha's Vineyard Summer Institute; he studied the development of the perforations in *Agarum* for his B.S. degree thesis at Harvard, though he turned to the Saprolegniaceae for his doctorate in 1892, and eventually he deserted mycology for cytology. Setchell, another student under Farlow, was obviously an appointment favored by him. Setchell returned in 1892 and subsequently through 1895, when he departed for the west coast. Obviously Farlow, already retiring from teaching at Harvard, was content to transmit his algal enthusiasms through his students. In 1896 a greatly enlarged scheme of botanical instruction was initiated under the leadership of Professor J. M. Macfarlane of the University of Pennsylvania, who had been trained at Edinburgh, but here again Humphrey and one of Farlow's students, George T. Moore, guided the work on cryptogamic botany. This brings one to the year of the great upheaval, but in 1897 B. M. Davis, another student from Farlow's laboratory, who had gone to the University of Chicago, took control and with G. T. Moore again gave the cryptogamic work. The greatly expanded list of botanical instruction soon was restricted, but Davis remained in charge, and Moore was associated with him until 1905. During this time various other additional instructors appeared, for algae in particular J. J. Wolfe from 1902–1906, again trained by Farlow. Moore took charge of the cryptogamic botany in 1906 and carried it through 1918; associated with him until 1914 was G. R. Lyman — a Farlow student — and others, including some Harvard-trained men, but probably none who were directly trained by Farlow.

Here, then, ends the immediate influence of Farlow and his students in this venture, which has grown from a handful of investigators in 1888 with most trifling equipment, to a group averaging over 360 for the five years before the present war, and about 125 students, with extensive equipment, large permanent buildings and a considerable maintenance staff. By 1900 it had become clear that the Laboratory was not to collapse; in spite of the adverse judgment of Farlow and his friends for which there was some justification, the administration rallied scientific and financial support, and went its way. Farlow never took further active share in it; neither, however, did he dissuade his students from doing so and under their guidance its botanical work prospered for thirty years. While it is extremely doubtful that Farlow actually was diverted from algal study to any great degree by the Woods Hole dispute, it is clear that for other reasons he was willing to let others do the research on these plants. By now he had two promising protégés, his student Setchell and an amateur, F. S. Collins, who was an accountant and business man of Boston and Malden. For the rest of our analysis of Farlow's influence we may go to his list of academic students and to his friends, their records and their correspondence with him.

A formal list of Farlow's students does not seem to have been compiled. From the congratulatory volume of photographs and letters sent to him on the occasion of his seventieth anniversary we may, however, glean the names of most of those of his students who specialized in algae at least for a time.

The first man, apparently, to take a doctorate degree under Farlow was B. D. Halsted, who in 1878 submitted his successful thesis on American charophytes. This was the nearest to a taxonomic dissertation that Farlow ever permitted a student to submit. Halsted became Professor of Botany at Rutgers College where his interests changed and he mainly concerned himself with plant diseases and the breeding of crop plants.

However, perhaps an earlier student contact was that with F. W. Hooper, who took a bachelor's degree at Harvard in 1875, but his master's degree only in 1898, and did not proceed to the doctorate. There is no record of significant phycological publication on his part, but he contributed Florida algae to the *Algae Exsiccatae Americae Borealis*. His interests shifted to other fields and he became Director of the Brooklyn Institute.

The next student was a very notable one, and for Farlow his appearance was a fortunate circumstance, because into his hands Farlow consigned with confidence the teaching of cryptogamic botany when his affairs induced him to drop it in 1897. This was Roland Thaxter, who took his bachelor's degree in 1882 and his advanced degrees under Farlow six years later. Thaxter's brief excursion into the algal field included especially his paper on *Compsopogon*, a morphological study. He then turned his attention to the fungi and became a very notable figure in that field.

At this period there came under Farlow's influence Kingo Miyabe, an able Japanese botanist who had had his early training at Sapporo. He took

his doctorate at Harvard in 1889 with his phanerogamic thesis on *The Flora of the Kurile Islands*. In later years he published extensively on the marine algae, and especially the Laminariaceae, of Japan.

While Thaxter was a student, three others were pursuing algal problems with Farlow. J. E. Humphrey took a bachelor's degree in 1885 and went out to teach at Indiana University; he returned to take his doctorate in 1892 with his thesis upon the Saprolegniaceae. He introduced the study of cryptogamic botany and especially the algae at the Marine Biological Laboratory, but his interests shifted to cytology in later years. While holding a post at Johns Hopkins University and in charge of a biological party in Jamaica, he contracted yellow fever and died in 1897.

R. P. Bigelow, likewise taking a bachelor's degree at Harvard in 1887, studied and published upon the structure of the adult growing point of *Champia*. He shifted his interest to zoölogy and held a professorship at the Massachusetts Institute of Technology.

In 1887 Farlow's friend, Professor Eaton of Yale, sent a very promising new graduate to study with him. This was W. A. Setchell who, like Miyabe, continued actively in algal research to the end of his long career. These were the only students of Farlow who did so. Setchell took a master's degree in 1888 and a doctorate in 1890, going eventually to a professorship at the University of California. His publications on the marine algae of the west coast are extensive and fundamental, but he had many and varied auxiliary interests which also led to publication.

G. J. Peirce took a bachelor's degree at Harvard in 1890 and thus came under Farlow's influence, though he went to Leipsic for his doctorate. Peirce was essentially a physiologist, and eventually Professor of Botany at Stanford University. He published on the relation of *Nostoc* to *Anthoceros*, gamete extrusion in *Fucus*, irritability in algae and on brine organisms.

The next year H. M. Richards likewise graduated from Harvard; however he continued and completed the doctorate in 1895. His early algal work dealt among other matters with parasitic algae; later his interest shifted to the fungi, wound reactions and the like. He held a professorship at Barnard College.

From this time on, all of Farlow's students held a bachelor's degree from another institution, although some added the Harvard one to it. B. M. Davis came to Harvard from Stanford University. Taking the master's and doctor's degrees in 1894 and 1895, Davis went on to a detailed study of algal distribution in the Woods Hole area for the U. S. Fish Commission, which was published in 1913. Although Davis's interest in the morphological side of algal studies continued, his actual research interest changed to plant genetics. He held a professorship at the University of Michigan.

G. T. Moore came to Harvard in 1895 and repeated the bachelor's degree, taking the master's the next year and completing the doctorate in 1900. His early interests were particularly in the freshwater algae; later the burden of administration kept him from activity in the field. He be-

came Professor of Botany at Washington University and Director of the Missouri Botanical Garden.

In 1897 E. W. Olive took a master's degree, and in 1902 a doctorate at Harvard. His early interest was in Myxophyceae, particularly their difficult cytology. Later his interests shifted to mycology and he served as curator at the Brooklyn Botanic Garden before leaving academic fields.

J. J. Wolfe came to Harvard, to take his doctorate in 1904, and made a cytological study of *Nemalion* which was well considered at the time. He did not continue with algal research. He held a professorship at Trinity College, Durham, N. C.

The next student at Harvard with claims to specialization in algae was R. F. Griggs. He took his doctorate in 1911 and studied the various features of the west-coast brown algae before becoming interested more in general matters of plant distribution. He holds a professorship at George Washington University.

Finally we may mention F. K. Butters, who took a second bachelor's degree at Harvard in 1900, returning to complete his doctorate in 1917. He studied especially the genus *Liagora* and was interested in Hawaiian algae, but later concentrated his attention on ferns and phytogeography, holding a professorship at the University of Minnesota.

Reviewing this list we see that only two men continued consistently in algal research. Four, namely B. M. Davis, G. T. Moore, H. M. Richards and R. F. Griggs continued profitably with algal work for a time, and then went on to other fields. In teaching no doubt these all transmitted something of their early enthusiasm; to the teaching at Woods Hole, largely algal, Humphrey, Setchell, Davis, Wolfe, Moore and their academic descendents, all contributed.

It is hard to judge the worth to science of these men. Some were active researchers, like Thaxter and Setchell, others administrators like Moore. Of the fifteen names, eleven carried the star with their listing in *American Men of Science*, indicating a considerable recognition by their colleagues; Humphrey died before the custom was initiated, and Miyabe was a foreigner and so not included. In the voting for the first edition, Farlow himself ranked first among botanists, Whitman second among the zoölogists, exceeded only by W. K. Brooks. Seven of Farlow's students were starred in this first edition, one being in zoölogy. Almost all of his phycological students came to hold full professorships in large and well-equipped universities, many being the departmental heads. That the actual output of algal research is not great for such a number over so long a period is probably related to the specialized character of the field and the few openings favorable to specialists in marine algae. The thread of inspiration was not broken, however, but carried on into the next generation through Setchell.

The topic of Farlow's relations with other botanists is too huge to develop fully in the space remaining for this article. One may well doubt if any botanist of his generation or since has conducted as extensive a per-

sonal correspondence. Farlow knew every phycologist of note, and kept the acquaintances active. The lesser men at home and abroad constantly referred material to him for advice; he in turn sent material overseas to persons in a position to give expert help, and thereby kept up the acquaintances established during his trips abroad. Farlow never cared for either an amanuensis or a typist; he wrote his letters, one may judge from some remarks, concise ones, with his own hand and seldom kept copies. The letters reaching him he kept, thousands of them, and in his later years he had them sorted and bound into scores of volumes. A person who had grown up with knowledge of Farlow since college days would be in a much better position than the present writer to extract a connected story of Farlow's life and friends from these letters. Only half of the story is there, the other half must be surmised, for in only such rare cases as those of Gray, Bornet and Collins has the other side of the exchange been brought into the Farlow library. The earliest correspondence certainly is missing, and there is no way of telling how much has been eliminated before what Farlow thought was important was bound together.

In the first place we must recognize that the bulk of the scientific matter in these letters consists of lists of identifications and notes on various plants, discussions of nomenclature and the like. From this, little suitable to the present presentation can be extracted. Of the general material only a few glimpses can be offered, to give an idea of the nature of the problems which were referred to Farlow for advice.

The first group of correspondents are those dating from Farlow's Bussey Institute period and his first European trip. Eaton, Anderson and Wolle represent the main American contacts of these days. Professor D. C. Eaton of Yale University, also interested in the marine algae, was for many years his best and most active correspondent. The exchange opens with a letter from Eaton describing the results of dredging under Baird's direction near Eastport, Maine. He writes that the dredge had brought up *Delesseria sinuosa* and *Ptilota serrata* from at least 400 feet depth. Two years later Eaton seems to have visited Farlow at Woods Hole for a collecting trip. The trip must have been strenuous, or at least ended in a rush, for Eaton accounts for the whereabouts of his own and borrowed attire after what one suspects to have been a classical attack of professorial absent-mindedness: "Dear Dr. ——— I remembered the coat before I left Woods Hole, but too late to reclaim it. Your night shirt I have here, & will presently send it to your Boston address by the Express Co. . . . I suppose you are having a real good time of it now your students have gone." (20 August, 1875). The next year begins a very long correspondence about the exsiccata for which Eaton and Anderson shared the responsibility with Farlow, which includes their own collecting and that of Edward Palmer and F. W. Hooper in Florida. In 1879 Eaton was proposing Farlow for a position at Johns Hopkins University, as he mentions having written to this effect to Mr. Gilman. Nothing came of it. In earlier letters it is Eaton's preoccupation with ferns which calls for apology, but from 1881 it becomes evident that

Farlow's interest was shifting to the fungi. Setchell's name is mentioned first in 1885 at a time when it is evident that these correspondents were building up their bryophyte collections; two years later a discussion of Setchell's plans appears, and in June Eaton refers with pleasure to his appointment at Harvard. Apparently Eaton did not think much of organized scientific groups: in 1893 he writes to Farlow expressing disapproval of a botanical congress: ". . . I have the heartiest possible contempt for the whole crowd of priority-worshippers . . . and shall not feel the slightest obligation to conform to their 'Laws'," and regarding an embryo organization in this country ". . . the longer I think of the botanical society the worse I think." There seems to have been close social contact between the families, and Eaton's daughter kept Farlow closely informed of her father's illness and death in 1895.

Dr. C. L. Anderson was the other partner in the *Exsiccata* enterprise. He writes to Farlow in 1876 expressing enthusiasm for the prospective series, and continues with letters regarding the specimens and labels for it.

Francis Wolle, clergyman head of a Moravian girls' seminary at Bethlehem, Penna., was an indefatigable student of freshwater algae, on which he published largely, his books on freshwater algae, desmids, and diatoms having a considerable vogue fostered by the numerous, if not very precise, illustrations and descriptions. The correspondence with Farlow lasted for about ten years from 1875, mainly with regard to specimens the identity of which was in question. Apparently Farlow distrusted Wolle's determinations and for this reason sent some of his specimens to Bornet for redetermination. From a last letter of 1884 we gather that the edition of the *Desmids of the United States* was limited to 460 copies, a venture with the initial success of which Wolle was quite pleased.

The foreign correspondence beginning in this period centers on Farlow's first European trip, and continues until when toward the turn of the century, these older botanists had passed from the scene. The earliest Agardhian exchange opens when J. G. Agardh (8 January, 1872) welcomes Farlow as a new correspondent, and indicates his desire for west-coast algae, especially Laminariaceae. Later that year, correspondence arranging for Farlow to visit Lund appears and the facilities there are explained. Twenty years later Agardh again writes to Farlow at Paris inviting him to revisit Lund, and in August expresses his pleasure in the occasion after Farlow had left. There was much reference to the notable "*Algae Muellerianae*" from Australia, of which he was sending a series to Farlow. Farlow's marriage in 1900 was greeted with the friendliest expressions and a congratulatory poem.

In 1873–74 we have letters from Farlow to Thuret and Bornet arranging for his visit to Antibes. Farlow was having the traveller's perennial difficulty of fitting his plans into the vacation plans of the Europeans. The correspondence with Thuret was necessarily brief, but that with Bornet was very extensive for many years. In 1874 he wrote to Farlow encouraging him to prepare an introduction to the algae of his region, *i.e.*, New

England, and telling him the gossip regarding the Antibes group of botanists which Farlow had lately left. Of course the correspondence dealt largely with determinations of Myxophyceae. They exchanged their major as well as minor works: Bornet in 1878 writes of sending the *Etudes Phycologiques* and in 1882 of receiving four copies of Farlow's *New England Algae* and of Hervey's *Sea Mosses*. In 1883 writing in reply to an account received of Farlow's trip to Minneapolis, he indicates the part which Longfellow's *Hiawatha* and Cooper's tales bore in forming his ideas of that part of America!

Correspondence with Areschoug, Hauck and very many others of lesser note exists, but lends little to the interest of this account. That with Sir Joseph Hooker is more significant; Farlow could act as intermediary and tell him of the waning health of his friend Professor Gray. Fairly early, in 1878, replying to a request for portraits of botanists, Hooker tells what he can supply and which exsiccatae he has in duplicate for exchange. Finally, in 1907 he acknowledges formal congratulations, received on attaining his ninetieth birthday.

With the next age group the importance of the letters shifts to the American field. Farlow is by now a recognized leader, and while his contact with older Europeans flourishes, he is not particularly impelled to active correspondence with the younger group. However, we find some new names, as contact was developing, for instance, with Hariot and Lagerheim.

Among Americans, we have now the period of development of Collins as a phycologist, Farlow's encouragement of the Curtiss family in botanical collecting, and the establishment of his earlier students. Frank S. Collins was a business man employed by the Boston Rubber Company in charge of their accounting. He had little leisure, but he employed it in ardent botanizing. He was quite as much interested in freshwater algae as in marine plants; from contributing to Dame and Collins' *Middlesex Flora* and the algae of Rand and Redfield's *Flora of Mount Desert*, through many smaller papers, he developed his *Green Algae of North America*. On his *Green Algae* . . . , the *Algae of Bermuda* which he prepared with Hervey's coöperation, and on his spectacularly successful *Phycotheca Boreali-Americana*, largest exsiccata of algae ever issued, his fame chiefly rests. His work was for its day very accurate and scholarly, particularly the smaller papers in which he described the novelties he later incorporated in his larger works. For much of this Farlow provided the critical background, the reference collections and encouragement, although ultimately Collins assembled an excellent herbarium and library of his own. As it was possible to confer personally, the amount of correspondence was all the more remarkable. The letters begin in April 1881, but refer to earlier matters, discussing trips to Nahant and Woods Hole, and the plants collected. In Oct. 1894 appears a sentence, ". . . I want to distribute this species, either in the *Phykotheka Universalis* or in the set which Setchell, Holden and I have been talking of issuing, if we ever get to it; and I don't want to give a new name only to have to take it back again." There is

much interchange at about this time regarding the C. E. Pease and E. Butler collections of Jamaican algae on which Collins was to publish. The queries about labels for the *Phycotheca*, to which Farlow contributed specimens, begin to appear and Farlow writes to Collins in February 1895 acknowledging the receipt of Fascicle I, and in April Collins writes ". . . I have sent out about all the first lot I made up of Fascicles I and II, and am laying out the specimens for another batch of the same." From letters to Setchell in 1908 it seems that Farlow was trying to secure money to bring Collins to the herbarium at Harvard, but that enough was not forthcoming. As early as Oct. 1901 Collins mentions that five or six years earlier he had done a good deal of work toward a book on New England marine algae, and that he now contemplated making it cover the whole east coast; this manuscript was never modernized and completed, but went on Collins' death with his collections to the New York Botanical Garden. This interchange, too long to follow through, only ceased with the death of Farlow in 1919, Collins dying the next year.

Another useful interchange, likewise outside the academic sphere, took place about this time between Farlow and the Curtiss family, Mrs. Floretta A. Curtiss and her son, A. H. Curtiss. Mrs. Curtiss, living in Florida, issued three series of *Marine Algae of Florida* starting in 1895, with many of the determinations by J. G. Agardh. Much earlier correspondence had been exchanged between Mrs. Curtiss and Farlow regarding various Florida algae, starting in 1877. Apparently Mr. Curtiss travelled much for government agencies; he also seems to have collected natural history specimens of all sorts for sale. Mrs. Curtiss especially cared for the algae, which her son rough-dried for her in the field, and which she soaked out and mounted. In 1899 he writes of his mother's partial paralysis and her desire to have her personal collection of algae, which contained much valuable foreign material received by exchange, gotten together for the U. S. National Museum. Three months later her death is referred to, and the plans for assembling the *Algae Curtissianae* into volumes for preservation. As late as 1904 letters were exchanged, but seemingly no more algae were to be expected.

Letters between Farlow and his student J. E. Humphrey began earlier, but extend into this period. What we have from 1888 tells of Humphrey's arrival at Indiana University, the lack of a botanical library, his plans to build up the department and his hope for separate departmental status. In 1897 the letters came from Johns Hopkins University, his last post. A curious exchange here illustrates the lack of centralized authority at the Marine Biological Laboratory at the time. Humphrey had been teaching the algae course there; he was preparing for his last Jamaica trip and was asked to secure a substitute. Humphrey arranged with H. M. Richards to come, but Director Whitman without consulting Humphrey or Farlow, engaged B. M. Davis and printed the announcement. Farlow and Humphrey were indignant at having the matter taken out of their hands without warning; Humphrey died on this Jamaica trip, but both Davis and Moore served on the Woods Hole staff repeatedly. This was no doubt one

of the items which collectively induced Farlow to sever his connection with the laboratory.

Except for the Collins correspondence, that with Setchell is the most important domestic correspondence relating to American algae. The first letter is one dated December 1885. Through Eaton, Setchell had sent a specimen to Farlow for identification which proved of interest, and Setchell was forwarding more of it. Then follow a series of letters dealing with *Lemanea*, *Batrachospermum* and *Tuomeya*. There intervenes next apparently a period when Setchell was ill with rheumatism and spent some months at Sharon Springs, N. Y., and did some field botanizing about there, but with land plants rather than algae. The work at Woods Hole comes up for conference in 1891, and various persons as Davis, Brannon and Rothrock are mentioned as students who later became well known in the botanical world. A perennial topic of discussion still, the Marine Biological Laboratory "mess" is at that time reported as somewhat better than it had previously been, but Setchell complains of the high room rent: $1.00 a week each, two in a room in the Gardiner cottage! Each summer there is more about Woods Hole, and in July 1894 he mentions settling into the then new Botany building. Next June from Yale he writes to ask Farlow to recommend him for appointment to a professorship at the University of California at Berkeley; this after testing the disposition of Yale to meet the competition and getting no encouragement, he reiterates, and tells that he will receive $3000 as department head. In December he writes from Berkeley of the pleasure at the welcome he received, says he has about 500 volumes in the botanical library and tells what other funds are available to him. M. A. Howe and W. L. Jepson were there as instructors; but Setchell felt that since Howe's interests were similar to his own, that Howe should go elsewhere so that the activities of the department might be diversified; he recommended him highly to Farlow and asked help in placing him. The early issues of the *Phycotheca* came in for discussion and Setchell writes appreciatively of Farlow's review in the *American Journal*. Later in 1896, when the large expansion of the botanical lecture list at Woods Hole occurred, Setchell wrote with some amusement ". . . I understand that Macfarlane wants a botanical garden at Woods Hole &c — &c. . . ." Apparently Setchell doubted the wisdom of such ambitious plans. Setchell wrote to Farlow in some detail of his trips abroad, as to New Zealand and Europe in 1905 and again in 1911, and of the algae he collected and those he saw at the British Museum, Kew and the Linnean Society's rooms.

M. A. Howe opened correspondence from Berkeley with a question on *Fucus evanescens*, and asks help on the identification of Pacific Grove algae. He mentions his paper on California hepatics as his doctorate thesis and as a collateral interest. In 1894 he wrote inquiring of any opening at Harvard and in 1898 there were some moves toward bringing Howe to the Harvard herbarium in charge of bryophyte work. The financial terms were set forth at some length, Howe being very explicit regarding what he

felt were the conditions under which he could come. Nothing resulted, however, and other applications to Missouri and Oberlin which he mentions likewise having petered out, he wrote hopefully to Farlow regarding obtaining the headship of the department at Berkeley, which went, however, to Setchell. The latter encouraging him to move, in 1897 he writes of having taken an assistantship at Columbia University. After a break, the correspondence begins actively again from the New York Botanical Garden, and a great many inquiries regarding various plants occur, as finally those during 1919 regarding the Bahama Flora. Howe was eventually the Director of the Garden, and his work on marine algae, while less extensive than Setchell's, was at least equal in quality.

It is not possible to follow the correspondence with European botanists through this period, but one must not fail to notice the friendly interchange with Alexander Gepp as it covered the period of his marriage to Ethel S. Barton, another English phycologist, her later very precarious condition due to tuberculosis, and death. An amusing reference to the compilation of the British Museum of Natural History catalogue occurs, which Gepp describes as having been made up by J. Britten, himself, Wiltshear the attendant, with two words contributed by George Murray. In Gepp's own words (5 July, 1905) "We were the scribes, & George Murray was the Pharisee who contributed but 2 words — viz his own name."

It is impossible for a person who had no personal acquaintanceship with Farlow to write as understandingly of his witty, friendly personality as his own students. One could hardly improve on the charming biographical account by Setchell [1] to which all should refer for details of his life and the complete list of his publications.

Without question Farlow dominated algal study in America for a considerable period, and represented it before European scientists. Also unquestionably this high regard was justified; the problem is to appreciate truly how this came about. It was not due to the quantity of publication which, respecting algae, was never great and for the later years very small. Nor was it due to the importance of the material studied, for with the exception of the New England report it was never comprehensive, nor in general were many new species described. It did not derive from the sumptuousness of publication, for his best work appeared in government reports, nor the elegance of the illustrations, which when from his pen were few, stiff and labored rather than skillful. So far as his publications go they, by the care in preparation, clarity and lack of error, confirm rather than accent his reputation.

One must recognize that the high esteem in which Farlow was held was due to other factors. In the first place he was skilled in gathering together collections. He developed a personal herbarium and library of rare excellence, including items scarce and costly even at that day. His collections

[1] Setchell, W. A. 1927. William Gilson Farlow 1844–1919. Memoirs Nat. Acad. Sci. **21** (4): 1–22. Portrait and complete bibliography.

were in only secondary degree the result of his own field work. Again excepting New England, where at a few places he did get a variety of material, his collecting was not extensive and did not contribute largely to his publications. Rather by purchase and exchange did he secure from others splendid representation of the flora of many parts of the world. These treasures he was quite willing for others to consult, under strict supervision. As a result the more active descriptive phycologists, such as Collins and Setchell, came constantly to him for consultation, appreciated his careful assistance, and spread his fame. In the same way his European travels and active correspondence served abroad.

Here then we have probably the clue to Farlow's most significant contribution. He developed the first good reference collections for algal study in this country. He published skilfully, if not abundantly. He encouraged several young investigators to attempt algal problems, gave them rigorous training in meticulous research, and the two or three most productive among these he assisted in every way, so that they in turn dominated algal studies in America after Farlow's own interests were largely forced to the fungi. Professor Farlow was, then, clearly more important as a promoter, developing resources and trained men, than he was as an investigator himself, and as such he fills a distinguished place in American botanical history.

For the hospitality of the Farlow Herbarium and Library, for access to Professor Farlow's extensive correspondence, and for patient help in using these treasures, the writer is greatly indebted to the kindness of the curator, Dr. D. H. Linder.

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2(1): 71–82 FARLOWIA January, 1945

FARLOW'S INTEREST IN AN INTERNATIONAL ABSTRACTING JOURNAL

FRANS VERDOORN [1]

In collecting data about the history of international relations and coöperation in the plant sciences, I have gathered a large number of letters written by the late W. G. Farlow. Dr. Farlow, though a charter member of the *Association Internationale des Botanistes*, took no great part in its activities. He has never been a member of the council or of one of its commissions. Yet, during his fruitful life he was in touch with more men abroad than most of his contemporaries and was particularly active in undertaking and developing exchange relations. He was greatly interested in various aspects of abstracting and listing the new botanical literature of the world. In this field he exercised probably more influence than is realized. The need of establishing a truly international botanical abstracting journal was felt and discussed by him at an early date.[2] Dr. David Linder has suggested that it would be useful to publish in this special number of *Farlowia* a few of Farlow's letters on this subject. They are not only of interest for the student of international relations but throw an interesting light on Farlow's attitude towards a number of other problems and persons.

Since 1890 dissatisfaction had been growing, both in the Old and the New World, about the way the *Botanisches Centralblatt*, at that time the only abstracting journal in our field, was being conducted.

In October 1900, Goebel, who had already repeatedly viewed his opinion about the matter and who had even been planning to establish a second abstracting journal in Germany, met Lotsy in Ambach and discussed the situation with him. Lotsy was much interested and subsequently held conferences with R. von Wettstein in Vienna, with M. Raciborski in Lemberg, and with S. Nawaschin in Kiev. In November 1900 he wrote Goebel about a definite plan to start a new international botanical abstracting journal, as well as an international association of botanists which would not only edit and publish the journal, but would also undertake many other things.

In the United States there was at that time no less dissatisfaction. In an address (December 27, 1899) to the *American Society for Plant Morphology and Physiology*, Dr. Farlow had spoken in detail about the need of either changing the *Botanisches Centralblatt* or establishing a new journal. A committee was then established consisting of Dr. Farlow, Dr. D. T. MacDougal and Dr. von Schrenk. This issued a first report on June 27, 1900

[1] The author is under considerable obligation to F. O. Bower, Sc.D., LL.D., F.R.S., of Glasgow and to William Trelease, Sc.D., LL.D., of Urbana, Ill., for their help in securing data about the history of international relations work in botany and for their permission to reproduce the letters reprinted in this article.

[2] Dr. J. C. Bay's earlier efforts in this field are not discussed in this article.

and a definite report on December 27, 1900. The committee, and Dr. W. F. Ganong, at that time secretary of the society, had been very successful. They obtained from Dr. O. Uhlworm, the editor of *Botanisches Centralblatt*, various promises, described in detail in Dr. Farlow's letter of February 4, 1901, reproduced below. As we will see from the following letters, Dr. Lotsy and his group went on with their plans and established the *Association* at a meeting in Geneva in August, 1901. The society acquired the *Botanisches Centralblatt*. We reproduce now three letters by Dr. Farlow which throw some interesting light on the events of that time. The first letter is addressed to Dr. Bower of Glasgow, an old friend of Farlow and also a friend and supporter of Lotsy and his work. The second letter is addressed to Dr. Trelease, a former student of Farlow, who was also much interested in botanical bibliography and who had undertaken to share in the work of the American editorial committee of the *Botanisches Centralblatt*, as referred to in Farlow's letter of February 4, 1901 to Dr. Bower. The third letter is again addressed to Dr. Bower. Lotsy's letter to Farlow, of which a copy is in the Chronica Botanica Archives, is not so impulsive or naïve as one may expect after Farlow's reaction. Lotsy was planning something much bigger than only a journal, he was dreaming of an international botanical bureau, as many others after him have done. Farlow was only interested in the journal and seems to have had little sympathy with Lotsy's plans and way of thinking.

Cambridge
Feb. 4, 1901.

Dear Prof. Bower,

I suppose that last June you received a copy of the report of a committee of the Society of Plant Morphology and Physiology appointed to consider the best means of securing a good record of current botanical literature. A second and final report was sent you about a month ago.

Assuming that the reports were received by you it is not necessary for me to repeat their contents now. The last report was presented by me as chairman of the committee at the meeting of the Soc. Plant Morph. in Baltimore on Dec. 27.[3]

After I returned from Baltimore I received a letter from Lotsy which took me entirely by surprise. I did not know that there was any project for a new journal of reviews in project. About six months ago, I believe, I had a letter from Goebel in which he expressed great dissatisfaction with the Centralblatt and said that he had sometime thought that he would like to start a new journal. But from what he said I did not understand that there was any intention of doing so now and the project seemed to me to be all in the air. Up to June of last year the reply of the editors of the Centralblatt to our suggestions for improving their journal had not been satisfactory to us but at the meeting of last June our committee was directed to continue negotiations with the Centralblatt and, if they would not do what we wanted, to present a plan of a new journal at the meeting of Dec. 27, 1900.

Early in November the editors replied agreeing to do all that we had asked

[3] *Cf.* Farlow in Bot. Gaz. **29:** 64. 1900. A further report was issued in 1901 by Farlow, MacDougal and von Schrenk.

them to do. They decided to put all their worthless articles into the Beihefte and to put all the reviews and the list of new works into the Centralblatt and also to allow one to buy the Centralblatt without the Beihefte (which nobody wants) at the old price. They also asked us to select American editors whose names should appear on the title page to see that American notices were kept up to the mark. They furthermore said that they hoped to have similar editors appointed by botanists in other countries.

Such an arrangement seemed to us at Baltimore to be a good one and a committee was appointed (of which I am a member) to inform the Centralblatt that their proposition seemed satisfactory and to nominate American editors. In fact, we have already selected one editor and have been considering other candidates.

You will imagine my surprise *after* returning from the Baltimore meeting on hearing from Lotsy [4] that a new journal was proposed and he wished me to join his International Association. I should be glad to join the Association were it not that its main object appears to be the starting [of] a new journal in opposition to the Centralblatt. Having, in perfectly good faith, gone so far in our negotiation with the Centralblatt it seems to me that it would not be honest for me, no matter how brilliant a list of names of associates Lotsy reports, to join now an association which is directly opposed to the Centralblatt. . . .

I have written this to you not knowing to what extent you feel confidence in Lotsy as a manager but merely wishing to let you know the circumstances which prevent my accepting Lotsy's invitation. I feel that we here are in duty bound to give the Centralblatt a fair trial under the proposed arrangement. It may or may not succeed but, if it does not succeed now, it will be in part our own fault. If it turns out that the Centralblatt people won't do as they should, then all the subscriptions will go to Lotsy's journal if it is a good one. I take it for granted that the Centralblatt people mean to act in good faith. Certainly they already have dropped original articles from the Centralblatt itself, and, as far as American editors are concerned there has not yet been time for us to select editors and, until that is done, one could hardly expect a change in the character of American reviews. As far as improvement in the quality of the notices is concerned, I should expect that it would be gradual not sudden and we cannot complain if it takes at least six months before a perceptible change is seen.

Yours, truly,

W. G. Farlow.

Cambridge, March 1, 1901.

Dear Trelease,

This noon I received a letter from Lotsy which quite took away my breath. After receiving my cable and letter saying that it was too late for me to accept his invitation to join his International Society since we had promised to help the Centralblatt, Lotsy decided *to buy the Centralblatt*. They have agreed to sell out to him and he now wants me to cable to him at once that I will join the new Society. I shall take the liberty of thinking over the matter until tomorrow morning. I have consulted Thaxter and he agrees with me in thinking that I can and should accept. The way things have turned out is, I think the best solution of the complication.

[4] For a biographical account of Lotsy *vide* Genetica **13:** 1. 1932.

Uhlworm [5] is to be kept for five years and the American editors we may select will be accepted by the managers. It is proposed to capitalize the Centralblatt at $10,000. Stock is to be placed on the botanical market and we shall have the opportunity to invest. The assets on hand are something like 100 complete sets of the Centralblatt &c. The whole thing seems very funny but I think it will succeed. The main point as far as we are concerned is that our Committee is practically tied up for the present awaiting the cons[u]mmation of the purchase by Lotsy. There is one snag in the way; the purchase must be confirmed by the board of the new Society. What the board is I do not know but I suppose that Lotsy's action will be endorsed.

It is too dark to see what I am writing and I must close.

Yours, truly,

[W. G. Farlow.]

Cambridge, April 5 1901.

Dear Prof. Bower,

Since I wrote to you in regard to my correspondence with Dr. Lotsy I have had another communication from him which surprised me even more than his previous letters. A week ago I had a letter in answer to my inquiry as to the individual responsibility of stockholders in which he said but little about the Centralblatt but instead wrote several pages describing a project of forming a sort of museum for collections of microscopical slides and type-specimens in general and a bureau for collecting all sorts of miscellaneous information for botanical travellers.

I presume that you have received a similar letter. The letter seemed so very visionary and reckless that I could not help coming to the conclusion that Lotsy is what we call a "crank." He certainly must have very little commonsense. To manage the Centralblatt so that it would become a first-class journal will be quite enough to absorb all his time and energy without launching out on any such wild-cat sort of speculation as his proposed museum. He stated that he needed an endowment of $130,000. He added that Goebel despaired of being able to raise that sum in Europe. I am not surprised that Goebel thinks so.

Lotsy however is confident that some of the numerous American millionaires will give him all he wants. He said that if I thought that I could introduce him to a number of our millionaires, he would start for America at once and come to Cambridge to see me. Unfortunately I do not know any millionaires and if I did, I most certainly would squeeze all I could out of them for our own botanical department which needs money very much indeed and I should never think of asking them to give anything to Lotsy for a museum. I feel sure that all our botanists who are connected with universities or other institutions would act just as I have said I would do. There is only one rich botanist in this country and he certainly would give nothing to Lotsy in any case.

I have not yet answered Lotsy's letter because he said that he was going to send me at once the proof of the circular to be issued in regard to his new Society. After I have seen the proof of his circular I shall be able to write to him something definite.

[5] Shortly after Lotsy's Association acquired the *Botanisches Centralblatt* he and Uhlworm quarreled. After this Uhlworm retired entirely. He may have had some part in abortive attempts, made in Berlin a little later, to start another abstracting journal. These plans, however, did not materialize (*cf.* letter of Thost to von Schrenk, 15 Jan. 1902, in Chron. Bot. Archives).

He will not be able to see me in Cambridge because I intend sailing for Europe on April 30. My plan of going to Europe is due to the fact that I have been asked to attend the celebration of the University of Glasgow in June as a delegate of the National Academy of Sciences. I am so busy that it will be difficult for me to leave then but there [are] certain matters of business for me to attend to in Europe and my wife has two nieces of whom she is guardian now studying in Paris and she wishes to go to see how they are getting along. Unless something happens to prevent, we shall start for Cherbourg on the 30 and after attending to my affairs on the Continent, we shall go to England and then to Scotland so as to reach Glasgow in time for the meeting on June 15. Therefore there is a chance that I may have the pleasure of seeing you in June.

Yours, truly,

W. G. Farlow.

Between January 1902 and the last year of the First World War, Lotsy edited the *Botanisches Centralblatt* with great care. Except for Schramm's *Botanical Abstracts* we have never had anything in our field that was as satisfactory as the *Botanisches Centralblatt* between 1902 and 1919. Without doubt it was more satisfactory in its early years than later when Lotsy became involved in many other activities. During this entire period, Dr. William Trelease acted as American editor ("Président du Comité National des Etats Unis"). He gave freely of his time and energy and has done more than any other North American botanist to report well in the *Botanisches Centralblatt*, then still the only abstracting journal in our field, on the dramatic progress made in the U. S. A. between 1900 and 1918. He had the coöperation of a small, rather constant group of American "Rédacteurs spéciaux." Of some of these men the names do not often occur in the columns of the *Centralblatt*. That the journal was not always too satisfactory from the point of view of the North American editors and their colleagues we may gather from the following two letters of Dr. Farlow:—

Cambridge, Mass.,
Jan. 27, 1908.

Dear Trelease,

I see no reason why your letter should not be sent to Lotsy except that — suppose that he lets you go? Then I do not envy you if you feel that you *must* go ahead and start an American journal. I understand your reference to the Americans as "prepared to start an abstract journal of their own when etc" to be a bluff rather than a statement of fact. My recollection is that when I tried to suggest a journal for giving abstracts of American literature I was very, very coldly received. Galloway I remember as particularly "pooh-poohy" and declared it impossible. In fact, I do not remember that anyone gave me any real encouragement. Perhaps you mean an American journal giving abstracts also of European papers. Ughm!

I had no confidence in any real improvement in the Centralblatt when I heard that Lotsy was to run it . . . He is impractical and given to putting all sorts of unnecessary irons on the fire. Still I suppose it was a question whether any better man could be got.

Although far from what one would like, it may perhaps be the fact that, as at

present conducted, it is as good as such a journal is *likely* to be. Some want notices like those in Engler's Jahrb. but that is impossible unless few things are to be noticed. The "sympathetic" notices as I have heard them called can only come from experts who have taken their time to read and use the books noticed and that takes a long time and experts are not to be depended on in a journal like the Centralblatt. People complain of Just [Botanischer Jahresbericht] that it is too far behindhand. For my part, I think that Just is as near perfection as anything of the sort can be.

I was sorry not to go to Chicago but I was too dreadfully busy and I was especially sorry that none of our other botanists could go but Goodale was not well enough and Robinson, Fernald & Thaxter were driven by the printer and Jeffrey had only that time for going after fossil material. Like us, I suppose that you have had a remarkable winter. I do not object to the mildness.

W. G. Farlow.

Cambridge, Mass.,
Feb. 10, 1908.

Dear Trelease,

While you are "jogging" the Centralblatt let me suggest one point where it seems to me that something should be done. I do not like the idea of giving notices in the Neue Litteratur. Why should not the notices be given all of them in the regular place? It looks as if the reviewers despairing of getting their notices into the regular pages smuggled them in in the Litteratur where no one would look for them. It is unjust to writers so noticed since it looks as if their papers were not worth noticing.

Generally for my purpose the very short abstracts in the Neue Litteratur are enough and that brings up the question, Why not give *all* the notices in this short form with the titles issued in Neue Litteratur? Who wants (see p. 24) more than a page of *Dittrich* & *Pax*, Herbarium cecidiologicum? The trouble is and probably always must be that a good many reviews are given to immature students who have no sense of proportion.

Yours, very truly,
W. G. Farlow

The *Botanisches Centralblatt* was first published for the Association by Messrs. Brill of Leyden and printed in Germany at the same press where it had been printed before it was acquired by the Association. Later it was printed in Leyden at Sijthoff's and published by Messrs. Fischer of Jena for the Association. Though the Association remained a purely international society till the end (in 1917 its council was formed by D. H. Scott, Wm. Trelease, and J. P. Lotsy, and its editorial board by Wm. Trelease, C. Bonaventura, A. D. Cotton, C. Wehmer, and C. H. Ostenfeld) and though its journal was edited and printed during the First World War in a neutral country, the fact that it was published in Germany and that much (without doubt much too much for an international journal) of the contents was in German caused highly complicated difficulties with American (not British!) authorities and resulted in only a few copies of the journal reaching American subscribers. This and other things caused considerable ill-will amongst a number of North American botanists. In Great Britain, where the international character of the journal was better understood, as Drs. Bower,

Seward and others have assured me, there never was any feeling against the journal or the society. Feeling dissatisfied, a group of U. S. colleagues, amongst whom Dr. Livingston was very influential, established at that time *Botanical Abstracts*.

This probably happened too recently to allow us to decide if it was wise to do so, especially as Dr. Lotsy, tired of the difficulties of keeping his journal going during the war years, offered the North American group the fullest possible coöperation of himself and the Association, a somewhat informal offer in which he would, without doubt, have had the backing of the Council. This offer was not accepted. It was hardly considered, which seems a great pity to the student of international affairs. As a result, we have two not entirely successful [6] abstracting journals from 1919 onwards.

Since this article is not primarily concerned with these problems, it may be more interesting for us to see what Dr. Farlow, then nearly seventy-five, had to say about these developments in 1917, 1918 and 1919 in his letters to Dr. Trelease, the chief American editor of the abstracting journal of the Association Internationale des Botanistes till its discontinuation.

Cambridge
Nov. 12, 1917.

Dear Trelease,

I agree with you entirely about the desirability of improving the Bot. Centralblatt rather than starting a new and similar journal in this country.

Reddick was here a fortnight ago and asked my opinion about an American Centralblatt to include everything in this world and apparently everything in the Solar System. I do not think that he favored it. His account of the genesis of the idea of an American Centralblatt was not altogether clear. He said that Stevens had been impressed by the success of the new American journal of bacterial diseases to which he said there were a good many medical men who subscribed. The universal success of that journal did not impress me because I had never seen a copy and had not heard anyone speak about it. If, however, as Newcombe appears to desire, the new journal is to include not only reviews of bacterial papers but also all papers on plant diseases and even botanical papers on non-bacterial or pathological subjects, I have an idea that the medical subscribers would soon drop out.

My first answer to Reddick was that it seemed to me to be folly to start a new journal of any kind at this time for financial reasons. Until the war is ended no one knows whether he has any money to spend or not and it is now evident that the war will not end for a long time if it is to end in favor of the Allies and, if not, Germany will take all the money that can be squeezed out of us.

Reddick said that it was expected (?) that the Brooklyn Bot. Gard. would furnish the money or most of it. My answer to that was that if Brooklyn furnished the money they would have to do with it what the Brooklyn people wanted and that the desires of those who did not furnish any money would not count for much.

[6] It is not the fact that they were commercially not too successful which I deplore, but the fact that none of them was truly international, while in 1919 we did have the framework of a truly international botanical society! *Cf.* also my remarks in Nature **154:** 595. 1944.

Furthermore, I told him that I did not desire to see established a new journal of reviews. As it is, I am loaded down with journals which give reviews of the same papers over and over again and unless the current journals would agree to give up reviews or notices of new papers I did not want to be bothered with more reviews. He said that he believed that Mycologia would agree to give up reviews. Mycologia, however, is practically the organ of the N. Y. Bot. Gard. and has no interest in noticing any work not done in connection with the Garden. Other journals probably would not agree to give up reviews as they help to sell the journals. Those who take only one journal would be likely to select that one which gave reviews in addition to original papers. The notices in the Bot. Gaz. for example certainly draw in subscribers.

Again I have little faith in the ability of our enthusiastic friend to produce a journal which would replace the Bot. Centralblatt. As you say, at the present time that journal does not help us as we do not receive the current numbers but after the war I presume that it will reach us as before. If the Centralblatt gives out later, then it will be soon enough to think about an American journal.

The Bot. Centralblatt certainly might be made better. I hope that it will. I have my own ideas of what is desirable. In the first place no author should be allowed to write a notice of his own papers unless he happens to write in a language like Japanese, or Czech perhaps, which is not readable by the ordinary editors. In the next place the editors should not be allowed to turn over papers to their students to review unless they themselves revise the reviews themselves. The younger students are not capable of writing good condensed reviews and, being paid by the page, there is no inducement to be brief.

My own opinion, not shared by some, is that in a Centralblatt, as far as possible all papers should be noticed as soon as possible after their issue and that the reviews should be *descriptive* not *critical*. That is, one should have the titles and a brief statement of contents of as many papers as possible so that everyone can tell whether a paper on subjects in which he is interested is one which he ought to look at and read. Really critical reviews are generally too long for a Centralblatt, they must be written by experts and they cannot be written at short notice.

Robinson does not agree with me. He thinks that reviews should be "sympathetic." That means I suppose in a review of a systematic paper there should be a list of at least the new species and perhaps others with comments. Those not interested in the subject would I think have little "sympathy" with reviews of that kind.

I really do not believe that there are any botanists to speak of who really want a new journal but at botanical meetings the crowd is easily persuaded to vote for anything proposed by a pleasing and plausible speaker. If the question comes up at Pittsburgh (I shall not be there) it may be voted to start the journal. Some very foolish things have been voted by the A. A. A. S.

The war news is certainly depressing and people here see no end of the war in sight unless it is to be very unfavorable. Our family have lately been rather anxious. My niece we hear has reached France. Her brother, an aviator, is on his way somewhere, we do not know where. Our available relatives are now all in Europe except one who is still at the Hydroplane school in Pensacola.

Remember me kindly to Mrs. Trelease.

Yours, very truly,

W. G. Farlow.

Cambridge
Febr. 26, 1918.

Dear Trelease,

Do you remember the *Guepinia lutea* Bres. which you collected in Alaska? I have recently received from near Seattle a Guepinia near *G. merulina* which may be your plant. We have here what I take to be *G. merulina* but it is rather rare. The Seattle fungus has spores which are rather larger and more septate than in our plant. The basidia are narrow and the tips are very short . . . but I do not know whether this is constant. I had only a very little of the Guepinia with a large junk of the host. I have written for more and, if I get it, I will send you some for comparison if you have any of the *G. lutea* on hand.

I am just sending in my preliminary ballot of the Nat. Acad. I put on the names of Atkinson and Forbes. The latter will probably be elected. About Atkinson I am more doubtful for there are some who are strongly opposed to him. At any rate I do not see how I can go to Washington in April to the meeting. It appears now to be practically impossible to secure a room at any hotel and the journey is subject to long delays. Prof. Palmer a short time ago was 27 hours on the road to New York. To be sure he was so imprudent as to take the boat on a very cold day and was blocked by ice.

Reddick was here two days ago and told me about the Pittsburgh meeting. O. L. Howard was also here apparently to make arrangements about the Ass. meeting in Boston next winter. He is down on Richards for advising giving up the last meeting. If next winter is anything like this and no more coal than now, the A. A. A. S. will not be welcome guests.

Both Reddick and Howard said that the Pittsburgh meeting was a *great* success. Reddick had become a convert to the new extract journal and he said that they were going to start work at once and get out the first number in June. It appears that the Waverly Co. of Baltimore which issues the bacterial extract journal thinks it can make a success of the new journal. It is supposed that the larger libraries would be willing to pay a good price if they receive slips during the year and the whole in book form at the end of the year with the right to buy other copies at a reduced rate. Something was said of charging $10 a year to individuals. I thought that not many botanists would want to pay that amount but Reddick thought they would if the journal was indispensable. The *if* seems to be important but also uncertain. The Brooklyn Garden was said also to be ready to help. I was told that it was Macdougal who was negotiating with the Waverly Press.

I wonder what you wrote on your card of the Man Power Census sent by Kern I presume. Not knowing what else to write I wrote "Mycology" diagonally across the card but Thaxter says that that will only show what a fool I am for only a short time ago a prominent Phytopathologist said that he thanked God that he was not a mycologist. A letter has just come from Whetzel asking me to attend a meeting in Boston on March 1st to organize work. I can hardly suppose that they want me to help them do the talking for they are already well equipped in that department.

Winter seems to be gradually slipping away. That is we now have some comfortable days as well as some very uncomfortable and March is still to come.

Yours, very truly,
W. G. Farlow.

Cambridge,
Dec. 27, 1918.

Dear Trelease,

Things are in a mess. I presume that the fact is that the Centralblatt management has become unpopular on account of Lotsy's . . . domineering and not conciliating [manners].[7] Chodat I presume represents the attitude of some Europeans outside Germany and they would be glad to see a rival established in some other country. Most Americans, especially the young men, seem determined to cut out the Centralblatt as too decidedly under German control. . . .

If Botanical Abstracts seems to fill the bill it will have a circulation abroad as well as here. My question is, will it fill the bill? The first number was not reassuring but later numbers may be better. Livingston's statement that botanists were much pleased with it would have more weight if I knew who the botanists were who liked the first number. . . .

At any rate, the war is now on. The Bot. Abstracts committee after Livingston's letter do not desire to conceal the fact that they propose to squelch the Centralblatt if they can. If I were you, I would wait until getting an answer to your letters of Dec. 24 to Livingston and Williams & Wilkins. They will have to say whether they intended to have their letters sent to the Ass. Intern. or not. Very likely you already have their answers. If they did intend to have their letters, or their contents, sent, then of course they should be sent. If they say no, all you can do is to tell Lotsy that you have communicated with Williams & Wilkins and that they have no intention of explaining or apologizing.

As to your own relations to the Ass. Int. Bot., if you have reason to suppose that its affairs are run by "secret diplomacy" as Chodat says or, if you have reason later to think so, you had better withdraw. Otherwise you will be in the position of endorsing measures which you know nothing about and may not approve at all.

Whether the abstracts will win the day is after all to a great extent a question of dollars and cents. Just now it is a matter of sentiment but in the end the question will be can we in America compete with the Germans in cost of printing and can we control at as small cost as the Germans a large body of reviewers, revisers, etc. No one knows what the condition of scientific workers is to be in Germany. It may be that the hitherto large number of trained men willing to spend their time in writing reviews, bibliography and what may be called dictionary work at a very small price will be much diminished. I am skeptical as to the reduced condition of Germany. I believe that they are still in good condition and really better off than France and perhaps as well off as England in equipment for scientific work. Of course much depends on what sort of a new government is formed in Berlin. So far at least the German leopard shows no signs of changing his spots.

Yours, very truly,
W. G. Farlow.

[7] Lotsy, his work and his personality, has often been criticized. He was, however, a great man, and has done more than anyone in the history of our *scientia amabilis* to promote international relations, coöperation, and understanding. Dr. Farlow's impression, without doubt shared by others at that time in the U. S. A. (but not in Great Britain, where Lotsy had more friends than anywhere else), of Lotsy's political sympathies is so erroneous that one can hardly understand it. It teaches us how easily misunderstandings may arise, during years of mental stress, even amongst the representatives of a single race.

Cambridge,
Dec. 31, 1918.

Dear Trelease,

A letter from Mangin dated Dec. 13 contains the following which will interest you.

"Nous avons eu à discuter la question de l'Association Internationale des Botanistes. Cette association est virtuellement dissoute et les membres ne (parviendront . . . word not clear but this as far as I can make out) la liquidation. Mais il serait utile de la reconstituer entre alliés et d'utiliser comme organe de cette association les abstraits botaniques qui ont fait leur apparition chez vous."

If I understand the above, the association is bankrupt which can hardly fail to be the case since subscriptions must have fallen off very much. I am a loser to the extent of $500, the amount of bonds I took. . . .

It seems to me just as well that the Centralblatt should stop. I should prefer an international reorganization to a purely American conducted journal but Bot. Abstracts has started in ahead. . . .

Happy New Year,
W. G. Farlow.

Cambridge
Jan. 26, 1919

Dear Trelease,

It is to be regretted that Mangin's letter to me and Flahault's letter to Duggar did not reach us before the Baltimore meeting. Had that been the case it would have been possible for you to state the facts contained in those letters to the representatives of Botanical Abstracts at Baltimore and you might (?) have been able to convince them of the desirability of trying to make some international combination which would result in making the Abstracts really an international organ.

Now, the case seems to be rather hopeless. It looks as if our younger botanists were cock-sure that our American botanists were better able than any others to issue an international journal. I hear that a contract has been made with Williams & Wilkins to run the Abstracts for five years. Of course W. & W. are not well informed as to the requirements of a real international journal and are quite satisfied that the Abstracts, as illustrated by the single number issued is just what is wanted.

The number issued did not strike me favorably considered as a general international review of botanical literature. It was really nothing but a guide to American botanical literature and the value of notices of papers in Bot. Mag., Torr. Bull., Phytopathology, Am. Journ. Bot. does not seem to me to be great since all our botanists practically see all those journals for themselves. Furthermore the comparatively large amount of space taken by Shull to review papers having no relation to botany is looked upon unfavorably by all botanists I know and, unless he is to be restricted in later numbers, the journal will suffer.

Flahault's letter is interesting. He speaks of the *possibility* of the non-germanic members of the Assoc. Intern. breaking up the agreement with Fischer and apparently is not sure whether it can be done. Of course it can be done for in these times international pre-war agreements count for nothing.

It looks to me as if the feeling against the Germans is too great at the present time to make it possible to form any international union. Opinions may be modified later but not for some time to come. Meanwhile the Bot. Abstracts is to be pushed in the hope that it will replace the Centralblatt. If it is to succeed in that object, future numbers will have to be very different from the first number.

There is no doubt, as you say, that an abstract journal with a German title would not be taken in the allied countries now. But any journal would have to give abstracts of German botanical papers as well as others. Such reviews need not be in the German language although I see no reason why they might not. There are certainly more botanists here who read German than who read Italian. It may be said, however, that one can often "guess" what the Italian means.

The meeting [10] in London referred to by Flahault appears to be merely the general meeting of scientific delegates and it could not have had any special significance for botanists. I should be glad to know what Scott's opinion is.

In short, the Centralblatt is dead and cannot be revived as a world journal under a German title and issued by a German house. . . .

From the point of view of science itself, I do not think that a union of English, French, Italians and Americans alone would be for the general advantage. There therefore remains the question, what are the chances that Botanical Abstracts will fill the place of the Centralblatt? That cannot be even guessed now.

I hear that the editors of Bot. Abstr. wish to raise a fund of $1000 to pay reviewers. That would not go very far and the Brooklyn Garden people or others specially interested ought to be able to get that amount without a general appeal. If their credit is no greater than that, the future is not promising. . . .

W. G. Farlow.

Though Farlow's interests were wide, ranging from the lowest to the highest of the cryptogamic plants, from general botany to taxonomy and phytopathology, from music to the humanities, though he travelled very widely and intensively in the interval between 1872 and 1874, and he also visited Europe thereafter, he was not in the broadest sense an internationalist, as were some of his contemporaries. His own collections came first and these he protected for future botanists by adopting measures, often criticized by his colleagues, that would as far as possible assure that the collection of books and specimens be available to future botanists. However, despite this preference for his own collections, he was much interested in the personality of his foreign colleagues, as Setchell (Mem. Nat. Acad. Sci. **21:** 14. 1927) has told us, but as a practical and typical New Englander, was still more interested in the results of their work and especially in the abstracting and listing of the botanical literature on a truly international basis. To this extent he was an internationalist, and as his early letters show, a pioneer in American abstracting work.

CHRONICA BOTANICA
WALTHAM, MASS.

[10] One of the early meetings of the *Conseil International des Recherches* (now *International Council of Scientific Unions*).

PLATE I

2(1): 84–95 FARLOWIA January, 1945

DR. FARLOW'S INFLUENCE ON MYCOLOGY

WILLIAM H. WESTON, JR.

In attempting to evaluate the imprint on a field of science made by an outstanding worker in that field it soon becomes obvious that lists of publications often tell but part of the story and that a man's influence may make itself felt through various channels less obviously recorded. In Dr. Farlow's case, even the partial list of his publications in two of the biographical memoirs noted in the introduction to this number, reveals that the scope of his activities was very broad including work on algae, bacteria, fungi, lichens, liverworts, mosses, ferns, and flowering plants. In addition he participated actively in botanical affairs for more than forty years, stimulated and promoted the development of several fields which were part of the rapid progress of botany in the United States during that time and played an active and constructive part in maintaining effective working relationships between botanists in this country and in Europe.

Withal it was probably the field of mycology which he influenced most strongly. On attempting to analyze his effect on this branch of botany, it becomes clear that his was a manifold influence making itself felt to some extent through his teaching, to some extent through his published work, but chiefly through his devoting to the service of mycology his wide knowledge of the fungi and his extensive herbarium, library, and indices on which this knowledge in part was based. The force which gave especial strength to all these lines of influence was the power of his dynamic, stimulating, and catalytic personality. His influence on mycology was thus of the same pattern as his much wider influence on the whole field of cryptogamic botany.

To understand the conditions which shaped his early aspirations into definite objectives that permanently motivated his life's work it is necessary to appreciate the status of botany in the United States during the formative years when Dr. Farlow began his training.

During the 1860s, botany as a science numbered very few professional devotees in its ranks in this country and was largely the avocation of those, such as ministers and doctors, earning their living in other professions. As an indication of conditions at that time it is worthy of note that Asa Gray, Goodale, Farlow and others in this country, like De Bary and numerous botanists in Europe, on graduation secured medical degrees because this was the only available degree involving training and graduate work applicable to botany and also because the profession of medicine would yield a

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Doctor and Mrs. Farlow on the porch of their summer home in Chocorua, New Hampshire. Picture taken a year or two before his death.

living permitting work in the unremunerative and precarious field of botany. Also, botany in the United States consisted almost wholly of work on the flowering plants with emphasis on their taxonomy, nomenclature, floristics, and gross anatomy. The leading exponent and symbol of this type of work was Asa Gray who from his contact with the botanists of Europe was well aware, upon his return from abroad in 1870, that rapid expansion of botany was beginning and if the United States was to keep pace, other aspects of the science should be developed. Accordingly, as he was fully occupied with his own field of work in the Fisher professorship of Natural History which he had held since 1842, he was instrumental in the selection and appointment of two promising young men well fitted to develop important fields in the rapidly expanding realm of botany.

The first, George Lincoln Goodale, by his skill as a teacher and lecturer gave impetus to the growing field of plant physiology which was rapidly assuming importance in Europe, and by his efficiency as an organizer and administrator built up the Botanic Garden, which already had more than half a century of development and service to its credit, to its final perfection of usefulness and beauty; he vitalized and enriched the collections of the Botanical Museum started by Gray around 1860 and brought about the building of the spacious and well-equipped Botanical Section of the University Museum.

The second, William Gilson Farlow, as the man to devote himself to the development of cryptogamic botany, was a wholly logical choice, for even before graduating in 1866 he had shown unusual interest and promise in that newly burgeoning field while his further preparation, through attaining his medical degree in 1870, was the same as that which Gray and De Bary, the two who influenced him most strongly, had themselves received. After being appointed Gray's assistant in 1870, Dr. Farlow worked with him for two years increasing the teaching emphasis on the lower plants, and carrying on research of his own, especially in the algae. Then, realizing the need for further training which only the laboratories of Europe could offer at that time, Dr. Farlow spent the two years from the summer of 1872 to the summer of 1874 travelling through England, the Scandinavian countries, Russia, Germany, France, Italy, and Switzerland and working in various laboratories, especially at Strasbourg in Anton De Bary's laboratory, at that time the world's leading center of mycological activity.

These were highly important years in Dr. Farlow's development. He met distinguished botanists and visited and worked in their laboratories, establishing valuable contacts and friendships which he maintained through correspondence and occasional visits for many years. He became acquainted with the botanists of the period, both the recognized authorities of the time and the students working with them, who were to become the leading mycologists and algologists of their generation. He visited the famous herbaria and libraries and the convincing evidence of their indispensable function as working tools essential to fundamental botanical work gained through his own use of these treasures, started him on the discriminating

purchases of books, periodicals, exsiccati, and specimens that were the nucleus of the Farlow Herbarium and Library so important in the ensuing development of cryptogamic botany in this country. Also in these two years he became aware of the trends and currents in botanical work and began to appraise what was fundamental and enduring, what held promise for future development, and what was merely transient in its temporary popularity.

The evidence seems clear that Dr. Farlow returned from his two years in Europe with the firm conviction that the development of cryptogamic botany in the United States would be aided most effectively by three essential facilities. First, there would be needed a herbarium of authentic reference specimens to facilitate dependable identification of critical material. Second, accompanying this reference herbarium an extensive and complete reference library on the fungi and other lower plants would be an imperative supplement for adequately identifying material and establishing its relationships and significance. Third, supporting both these, there would have to be an index comprising all significant published references to such material. One gains the impression that this enduring conviction was not so much the result of his earlier training with Gray as it was the logical outcome of his own analysis, during these two years, of the fundamental basis of botanical supremacy in Europe. There he saw, beneath the fads and fashionable trends which were gathering those adherents who gravitated naturally to the most publicized aspects of botany, the sound foundation on which botanical progress in Europe had depended. He realized the interdependence of such fundamental aspects of the science as taxonomy, morphology, and physiology, and retained his sense of proportion throughout his work in De Bary's laboratory where, even in the 1870s, the development, reproduction, life histories, parasitism, and other activities of fungi were stressed and taxonomy was rather looked down upon as old fashioned, the systematists with their vasculi being significantly and disparagingly dubbed "Heusammler." There he worked on the morphology, development, and reproduction of fungi and other cryptogams and there he completed the work on the apogamous development of *Pteris*, work which, on publication in 1874 immediately attracted wide attention, a pioneer contribution to a field later developed by others to far reaching significance. His brief but vivid pictures of the atmosphere, activities, and personalities in De Bary's laboratories as well as in others, such as Bornet's, in which he worked for shorter periods are interesting sidelights on botanical history, enlivened by his characteristic humor and well worth seeking out in the bibliographies already noted.

In the biographical sketches which appeared after Dr. Farlow's death, there is detectable a tendency to apologize for his not too extensive list of published contributions. This is hard to understand for certainly his biographers were well aware that the major part of his activity had been the accumulation and working over of collections not as an objective in themselves but as an essential working tool applied to the service of cryptogamic

botany. After Dr. Farlow's death in 1919 his herbarium, when officially taken over by Harvard, comprised around 500,000 specimens and the greater proportion of these had been studied and worked over critically by Dr. Farlow himself. Many of them bore enlightening notations in his characteristic handwriting, evidence of their having been compared critically with exsiccati, type specimens, and other pertinent material and carefully studied in relation to the significant and authoritative literature. No one who has consulted his extensive herbarium can fail to realize that it had been worked and reworked by Dr. Farlow until it became a fundamental part of his knowledge, his first hand familiarity with this material and with the wealth of original work in the extensive library he accumulated being the basis of his impressively wide knowledge so valuable to many workers in this country and in Europe.

The list of his publications is ample evidence of the breadth of his interest and knowledge since it ranges through the cryptogams from the algae to the ferns, and in the fungi, which have the major emphasis, touches on all of the chief groups from the bacteria and Myxomycetes up through the Phycomycetes, Ascomycetes, and Fungi Imperfecti, to the Basidiomycetes. Here are found the several published lists comprising some of the many fungi studied and identified by him, fungi representative of many different localities, some collected by him and by his associates in the vicinity of Boston, in the White Mountains, and elsewhere in this country, others brought back from the arctic by the Peary expedition or by other expeditions from such regions as Alaska and Labrador, or the Galapagos and the Bahamas, or from Bolivia and elsewhere in South America. Here are pioneer contributions to the field of plant-pathology, the papers on the Potato Rot, American Grape Vine Mildew, Black Knot of Cherries, and Diseases of Orange and Olive Trees in California representing part of his work at the Bussey Institution under his appointment as Assistant Professor of Cryptogamic Botany at Harvard from 1874 to 1879. There are also numerous more general papers in this field discussing common diseases caused by fungi, diseases of fruit-bearing trees, fungous diseases important in Massachusetts in various years and injurious fungi of California, while forest pathology shows a few pioneer papers on diseases of forest trees and diseases of trees following mechanical injury, and there are numerous studies of rusts, smuts, mildews, blights, and other fungi pathogenic to crop plants. There is also a brief note, in 1881, on the identity of a fungus found growing in the human ear, one of the early contributions in this country to the field of medical mycology, destined for rapid development forty years later. Papers on the edibility and poisonous quality of mushrooms and on the diseases of mushrooms with notes on truffles and other rarities are evidence of his interest in these economic aspects of the fleshy fungi as well as in their identity, classification, and relationship. There are notes also on some of the more spectacular aspects of mycology such as the identity of the fungi stored up by squirrels, the fungous diseases of insects, the mimicry of fungi by insects, the famous ginger beer plant with its combination

of yeast and bacteria collaborating to produce a liquor more or less potable, and the nature of the spots of rose leaves thought to be a fungous disease but in reality merely the adherent sporangia explosively discharged from a mold growing on the mulch below, a phenomenon that still continues to mislead botanists of the present as it did those of Europe and the United States in 1886.

His publications offer convincing evidence that even though his interests were primarily in systematic botany in its broadest sense, yet he was never oblivious of the practical importance of various aspects of cryptogamic botany and when need arose, turned his capabilities to such problems with telling effect, producing pioneer work of significance in several such fields. In plant pathology his work stands with that of Burrill and other pioneers as the first in this country, the beginning of a rapid development that within two generations gave preëminence in this field to the United States. Similarly his study of the pollution of drinking water by fresh water algae was a classic, pioneer investigation paving the way for the later development by Moore, Kellerman, and others, of this field of applied algology.

Even more than by his publications, however, he contributed to the advancement of botany by the services his herbarium, library, and indices, as well as his own knowledge, stimulus, and counsel rendered to workers in many areas of that rapidly expanding field of science. Here was available authentic reference material unequalled by any similar assembly in this country, a source where under the authoritative and interpretive guidance of Dr. Farlow, the interested seeker could find the answer to difficult questions as to the nature, identity, and relationship of the lower plants. Although such service is hard to estimate in quantitative terms, yet it was probably of the greatest value to mycology for while the library and herbarium covered the whole field of cryptogamic botany, the herbarium comprised more fungi than all the other specimens of algae, lichens, and Bryophytes combined, while the two Indices were devoted to the fungi alone. These facilities served, in the case of potentially harmful fungi, as the fingerprint files and criminal records from which the identity and dangerous characteristics of poisonous, injurious, or disease producing fungi could be determined with certainty, and, in the case of fungi potentially valuable to science, industry, or agriculture, as the personnel roster from which their names, locations, and capabilities could be ascertained. Visiting scientists in increasing numbers sought this center, coming from laboratories and institutions from all parts of this country and even from Europe, while by correspondence and exchange or loan of specimens and other material the service rendered by Dr. Farlow and the herbarium was extended even more widely. The numerous published acknowledgments frequently occurring in the significant contributions to botany over a period of nearly fifty years eloquently witness the effectiveness of this aspect of his participation in the development of mycology.

Dr. Farlow's influence on cryptogamic botany and on its specialized branch of mycology began through his teaching in 1874 when on returning

from Europe he was appointed Assistant Professor of Cryptogamic Botany at Harvard University and commenced work at the Bussey Institution in Jamaica Plain. There, along with his investigations of plant diseases, he guided the research of advanced students, the first of whom was Byron D. Halsted, while two days a week he gave more elementary instruction in general cryptogamic botany to undergraduates in Cambridge and in the summer gave similar instruction in summer school. After five years of productive activity in this dual rôle, he relinquished his work at the Bussey and under his appointment as Professor of Cryptogamic Botany in 1879 devoted all his time to a full program of research, teaching, herbarium work, and other activities in Cambridge. In 1891 he secured the appointment of Thaxter, one of his most promising Ph.D.'s then working at the Connecticut Agricultural Experiment Station, to carry on the undergraduate teaching while he travelled and worked in Europe and on his return in 1892 resumed only the instruction of graduate students working for higher degrees and the guidance of other investigators coming to the laboratories from the United States and abroad to carry on advanced research under his direction. In 1896, to devote himself untrammeled to the steadily growing herbarium, library, and indices that had become ever more important and widely known, he relinquished to Dr. Thaxter even this advanced instruction and guidance although his helpful and stimulating influence on graduate students through occasional contacts continued until shortly before his death.

Thus through seventeen years of undergraduate courses and twenty-three of official graduate instruction his influence as a teacher made itself felt on a long list of men from students gaining chiefly general pre-medical background to advanced workers who became important figures in various fields of botany. Of the courses he gave it was the general survey of cryptogamic botany variously designated in successive catalogues that most effectively demonstrated his unusual ability as a teacher. This covered the structure, development, reproduction, relationships, classification, and importance of the lower plants, a stimulating and challenging course with characteristically enlightening and enlivening lectures by Dr. Farlow and with strong emphasis on the laboratory study of representative types especially of the algae and fungi. He was at his best in the laboratory where his practical and psychologically sound approach of leading on the student by patient but persistent questioning used this plant material as a means for developing the student's latent capabilities for accurate observation, effective interpretation and precise description. His methods of inducing the student by his own efforts to master the difficulties of interpreting three dimensional features of complicated solid structures through interpreting the two dimensional visual images seen through the microscope were highly effective. A modern teacher might wonder what sections of a block of pine wood might have to do with cryptogamic botany or with mycology but as applied by Dr. Farlow, the study of this complicated structure became a highly challenging and enlightening initiation and apprenticeship to the

student with any spark of initiative or resourcefulness. Some of Dr. Farlow's convictions on the basic philosophy of teaching, the importance of the student's seeking and obtaining his answers from the material itself through his own efforts, are well brought out in his few articles on teaching, especially in his paper in the Scientific Monthly of 1886. Here the interested reader will find a discerning portrayal of some of the "modern" methods of teaching biology with a keen analysis of the types of students he finds in his own classes today and no teacher, no matter what school of education may have given him his training, can fail to profit by reading this paper of fifty years ago.

The facilities for this undergraduate teaching would now be considered meager. The microscopes were the early type Leitz, the low power focussing achieved by means of adroitly twisting the barrel in its friction collar, the high power focussing accomplished by a very simple but effective lever mechanism. Crude though they seem to the modern student, these little microscopes are still capable of excellent work in the hands of a discriminating user and several of them, fifty years later, still in good working condition, have given excellent service on field trips to present members of the staff. As there was no botany building until 1890, his courses were held in various buildings, one being Boylston Hall which still survives after years of service as a chemical laboratory, as a library, and in other capacities despite occasional arsonous attempts of students to do away with its gray grimness. From Dr. Farlow's class records it can be assumed that it was even more cheerless then than now for entries, during the winter of 1879, in his characteristic handwriting, record: "January 7: Lecture on Fucus and Vaucheria. Laboratory too cold for work. January 8: Lecture on the Peronosporeae. Laboratory too cold for work," while on January 14 it is safe to assume that milder weather enabled the class to make up for lost time as there was no lecture and the laboratory successfully covered *Fucus*, *Cystopus*, and the Saprolegniineae. Also, in these records there is a suggestion of the locker trouble which still afflicts the biology teacher, for in June, 1878, after the class of ten (six seniors, two juniors, one Divinity School and one Lawrence Scientific student) had successfully completed Natural History 9, he notes with relief that the microscopes (borrowed from the Botanic Garden and the Bussey Institution) are all accounted for but a new key will have to be made to replace the one missing for locker 16, although fortunately key #9 can do double duty as with a little coaxing it can be used for locker 8 in place of its own key, now lost. Incidentally it is of interest to note that Alfred Worcester, who became a leading and dearly loved physician in the vicinity, had locker 3 in 1877–78, Wm. Trelease, later Director of the Missouri Botanic Garden, had locker 1 in 1880–81, while in 1881–82, Wm. Patten, later widely known for his theory of the evolution of higher vertebrates from the Ostracoderms had #4 and Roland Thaxter #1.

The general course in cryptogamic botany served primarily to give a foundation knowledge of the lower plants to premedical and other students

concentrating in biology, and it fulfilled this function most ably giving the students also the training in observation and interpretation already noted and stimulating them with the enthusiasm and ideals which were essential ingredients of Dr. Farlow's teaching. Some, however, such as Thaxter, found in this course and in the more advanced ones to which it led, the impetus in mycology as a life work, hence even this undergraduate teaching contributed in some measure to Dr. Farlow's influence on this field.

It is for his guidance and training of more advanced workers that Dr. Farlow was best known and therein lay the major influence of his teaching on mycology. Stimulating in his leadership, exacting in his requirements, unfailing in his extensive knowledge, he contributed notably to the development of the men who carried on advanced work under his direction and guidance. It is significant that the problems he suggested for these men were almost without exception in the fields of morphology, histology, cytology, development, or parasitism rather than taxonomy. This was because, from the breadth of his own experience, he realized that such work would afford them better training than premature attempts at taxonomic monographs of various groups. Also he realized that systematic botany in its broad requirements needed all the evidence available from the rapidly developing fields of morphology and physiology as these, in turn, were dependent on taxonomy. In the testimonial volume of letters and photographs given him on his seventieth birthday, there is an impressive list of some fifty-eight workers who had studied with him or benefited from his guidance in the Cryptogamic Laboratory between 1874 and 1914. Among them are some who had become outstanding figures in algology, others had contributed notably to zoölogy, medicine, bacteriology, or even more specialized fields while the greater number were those who had played an important part in developing mycology and plant pathology in this country. The names of these men are eloquent testimony to the influence of Dr. Farlow's teaching; here are the algologists Setchell and others, discussed more fully elsewhere in this number; here are the outstanding teachers such as Lyman, Butters, and Grover; the famous men of medicine such as Kelly; the bacteriologists such as Barber; the botanists who contributed notably to physiology, genetics, cytology, taxonomy or other branches, men such as Blakeslee, Duggar, Davis, Robinson, Peirce, and Oakes Ames; the plant pathologists and mycologists such as Clinton, Rorer, Johnston, Faull, Schrenk, Fink, Riddle, Burt, Jackson, and Thaxter.

All the aspects of Dr. Farlow's influence on mycology and indeed on the whole field of cryptogamic botany whether through his teaching, research, or herbarium activities derived power and enhanced effectiveness because they were quickened and vitalized by his personality. In him there was no dullness nor stolidity, rather he was dynamic, highly active, quick of mind and motion, congenial, witty, and stimulating. Any discussion in which he participated was activated through his participation, any meeting he attended was enlivened and enlightened by his presence, any scientific move-

ment in which he took part was given impetus. Even as a student he had shown the qualities of leadership and as his prestige grew through years of constructive activity it was the stimulus of his personality as well as the soundness of his judgment and the scope and accuracy of his knowledge that made him one of the leading figures in American botany.

In the biographical sketches which appeared after his death, especially in the excellent memoir by Setchell, are many revealing glimpses of Dr. Farlow's personality, while the spontaneity of his wit and the deftness of his humor enliven the pages of his contributions. Some of the many stories concerning him have already been written, numerous others are treasured in legend. A couple of these, apocryphal perhaps, are yet so characteristic that they may not be out of place here. For example, it is said that his method of informing Dr. Thaxter of his engagement to Lilian Horsford was to remark at the end of one of their daily discussions of laboratory affairs, "By the way, did you know that Miss Horsford is engaged?" and on Thaxter's astonished reply "No, to whom?" his answer was "To me, of course." Also, as an instance of his ability to deflate pomposity there is the story that once, when he was crouched, digging in a patch of shrubbery by the side of a road near Chocorua, a dowager driving by with all the pomp and circumstance of footman, driver, and prancing team of horses, imperiously stopped the equipage and called out "Little boy, who are you and what are you doing here," at which Dr. Farlow straightened up and with impressive dignity answered, "Madam, I am Dr. William Gilson Farlow, Professor of Cryptogamic Botany at Harvard University and I am collecting hypogaeous fungi," at which disconcerting and unexpected reply the woman is reported to have driven rapidly away.

Those of us who were fortunate enough to have had even a slight association with him as graduate students looked upon him with awe because of his attainments, and delight because of his whimsical humour. While I was in charge of the teaching laboratory as Dr. Thaxter's assistant, Dr. Farlow liked to use the large tables on free days for sorting specimens and his comments, while rapidly shuffling packets from one herbarium folder to another and critically looking over new accessions, were worth straining the ear to hear and such straining was necessary, for in his rapid sorting, both hands would be busy and he would frequently hold one or two packets between his teeth. Yet even when thus occupied he would carry on a running fire of comment on the specimens, with anecdotes of those who had collected them and reminiscences of his own collecting trips. It was on one such occasion that he spoke of collecting algae on the West Coast and drying his specimens in his hotel room using the iron bed, which he had turned upside down and festooned with cords, as an improvised drying rack. His imitation of the Chinese houseboy opening the door, taking in the situation with one glance, uttering a wailing "A-wah, A-wah" and retiring for a more favorable opportunity to tidy the room, was unforgettable.

In some of the biographical sketches his quick, light step is noted. This step was familiar to all of us in the laboratories, as we noted also his char-

acteristic habit of taking a couple of shorter, quicker steps just before coming to a threshold, then hurdling the threshold as it were and taking a few more quick steps before resuming his regular pace. For this characteristic entry I used to listen, for he had a way of trying out my reactions on material he was studying, seeking, no doubt, the opinion of the general public of less experience and lower I.Q. in addition to the expert opinion of Dr. Thaxter. On one occasion he brought in two slides, asked me to compare them and after watching me examine them carefully under high power asked my opinion. My reply, noting their general similarity but pointing out certain differences, seemed to please him highly and he rapidly departed with the slides remarking "Very interesting, some people seem to have thought they were the same." When his note in Science in 1912 appeared shortly after, I realized he had been showing me some of the critical material on which his transfer of the chestnut blight fungus from Diaporthe to Endothia was based.

It was typical of his geniality that he would invite all of us, graduate students and investigators in the laboratory, to his house for occasional dinners. Those were memorable evenings. Mrs. Farlow, gracious and kindly, presided at the table over a dinner excellent and sumptuous, in striking contrast to the meager Foxcroft Hall menu which the limited finances of most of us permitted. Then followed examination of priceless volumes in the small fire-proof room which projected toward what is now the Faculty Club; perhaps some music in which he showed himself a versatile and accomplished pianist; and certainly reminiscences and anecdotes of his own experience and of well-known mycologists and algologists here and abroad, unforgettable to us who were just beginning our mycological work. On one occasion there was discussion of ant lions with which, of all of us, only Owen Burger was familiar from his work in Florida and I remembered well Dr. Farlow's vivid demonstration, on the deep piled Oriental rug, of the proper posture to assume while calling "Doodle, doodle" to the ant lion in the right pitch to jar him with the vibrations so that he would emerge from his hiding place in the center of his effective sand trap. (Incidentally, some years later in the Philippines I found this technique successful with the ant lions under the eaves of my house at Los Baños even though the magic words are certainly not Tagalog!)

All of us working in the laboratory at that time received some measure of help in our research and large measure of inspiration in our lives from our contacts with Dr. Farlow and this was in 1911 to 1915, only a few years before his death and long after he had, officially, relinquished all direct contact with teaching. Still treasured in my collections are specimens he gave me to facilitate identification of algae I had gathered at Woods Hole and around Halifax, Nova Scotia; but one of many instances of his helpfulness toward all of us.

That his aid to the younger generations of botanists was not only scientific but in many cases financial is less well known, largely because such aid was very unobtrusively and often vicariously and anonymously achieved.

Setchell mentions one or two such instances and Mangin gratefully acknowledges other cases in which French botanists were benefited while many others have received only private, though equally grateful, recognition.

To the beginner as well as to the expert, the assistance of Dr. Farlow's incomparably broad and expert knowledge was ever available if sought, and as his prestige grew he occupied a position of esteem highly regarded in this country and abroad as the final authority in difficult questions in the taxonomy of the lower plants. Because of his wide contacts with the work going on in this country and Europe, his familiarity with a wider range of workers and laboratories, his grasp of important developments in various fields, his opinion was sought not only in taxonomic problems but also on questions of general policy and purpose. It was the combination of his accomplishments and his personality that made him the spokesman and representative of mycology for many years.

Finally, as an adjunct to all the other channels through which he influenced cryptogamic botany and especially mycology, the part he played in fostering and promoting publications should be noted. He was the first of the American editors of the influential British periodical *The Annals of Botany* and, through his efforts over several years, it was strengthened by notable contributions from workers in the United States. In 1883, as the volume of work accomplished by investigators in his laboratory began to increase, he started the well-known series of "Contributions from the Cryptogamic Laboratories of Harvard University" and in 1896 when he relinquished the guidance of research workers to devote himself to his other activities, the numbered publications in this series, together with a few similar contributions for one reason or another not included, had reached over forty. Each of these papers by students or associates was within its limits a significant contribution and the whole series has materially advanced the development of botany. This very periodical, *Farlowia*, itself is not only a tribute in name to Dr. Farlow, but concrete evidence of the ways in which his influence on mycology and other branches of cryptogamic botany still makes itself felt.

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2(1): 97–141 FARLOWIA January, 1945

THE BOLETINEAE OF FLORIDA WITH NOTES ON EXTRALIMITAL SPECIES

I. THE STROBILOMYCETACEAE

ROLF SINGER

The present paper is intended to be the first of a series of monographic studies devoted to the basidiomycetous flora of the State of Florida. For the first time an attempt will be made to treat taxonomically the Boletineae of a large region with due consideration of the anatomical and chemical characters which, according to the author's view, are of no less importance in the taxonomy of this group than are adequate macroscopical descriptions. Considering the many inevitable changes that will be noticed when this paper is compared with the traditional American and European system of classification, the author has thought it necessary not to confine himself to the discussion of the species occurring in Florida. While giving complete descriptions only of Floridan species, notes on extralimital species have been added in order to avoid the mistake bound to impair the work of the locally minded taxonomist. At the same time, this procedure seems to offer the only means of providing all the evidence for the solutions proposed in this paper. This seemed especially important in some thus far controversial groups such as the Strobilomycetaceae, Jugasporaceae, and the genera *Pulveroboletus* and *Phylloporus* (Boletaceae). It will also illustrate the specific representation of Florida fungi in the world flora of Boletineae. Another factor determining the present arrangement was the author's wish to coordinate European and American nomenclature and classification. As a matter of fact, many so-called American species have been known previously to European mycologists under other names, and many European species have turned out to be later synonyms of species published by American authors. In the case of *Boletellus ananas* and *Strobilomyces pallescens* a similar situation has developed between this country and Australia.

The mycoflora of Florida is especially fascinating as a part of a transitional vegetation, changing from the North American temperate flora into the neotropic flora of the West Indies and South America. This transition is a very gradual one, the northern and the southern elements overlapping each other's areas of distribution until, in a comparatively narrow zone along the south tip of the peninsula it becomes more truly tropical. Nevertheless, while not all of the representatives of tropical South and Central America reach South Florida, there are still some more northern elements following the species of *Quercus* all through the peninsula. The extratropical part of what is usually called South Florida, and Central Florida up to a line running somewhere through North Florida is characterized by a progressive (towards the north) increase of the absolute number of species

of Boletineae observed, and also by the progressive increase of the percentage of northern elements, and a progressive division of the fungus flora into a thermophilous summer flora, and a more hardy winter flora. While all tropical elements reaching as far north as the zone where this bi-seasonal fruiting period becomes most distinct naturally belong to the summer crop, and all the truly northern elements belong to the flora appearing during the winter rainy period, it nevertheless is true that some unexpected fruiting periods are observed for certain species, e.g. *Boletellus Russellii* with the center of its area far to the north, still appears among the summer-fruiting species. The bi-seasonal division rather seems to follow generic lines: with very few exceptions the genera *Strobilomyces*, *Porphyrellus*, *Boletellus* (i.e. all Strobilomycetaceae), all Boletaceae except *Suillus*, and the genus *Clitopilus* belong to the summer-fruiting group, while *Gomphidius*, *Suillus*, *Paxillus*, and also some single exceptional species of the Boletaceae belong to the winter-fruiting group. These seasons are strictly parallel with the main periods of precipitation in this part of the state, i.e. June to August, and depending on yearly fluctuations, frequently also in May (even April) and September (October) and again in December and January (sometimes including November and February, or even a part of March). The periods between these rainy seasons are not altogether devoid of fungus growth, but only very exceptionally will any representatives of the Boletineae be found during the dry spells between the main seasons, and never will a typical summer species be collected in winter or vice versa. It will be remembered that a somewhat similar situation has been reported from Cuba by Berkeley and Curtis though their statement regards only the montane zone. A very interesting fact, noteworthy in this connection, is the discovery by the writer of true seasonal dimorphism in boletineous species in Florida. Two species, *Suillus hirtellus* (Peck) Snell and *Suillus australis* Sing. ined., show morphological and chemical differences according to the period of appearance and these are constant in different regions and analogous in both cases cited. They will be discussed in the second part of this paper.

As for the association of the mycorrhizal fungi with certain hosts, we have some interesting examples of specialization in Florida. While it is generally assumed that there is little evidence of a mycorrhizal association with forest trees in the tropics, the occurrence of several species of pines down to the south tip of the peninsula and in the Caribbean area, and also the presence of many species of *Quercus*, explain the fact that Florida, even the tropical zone of the State, makes an exception of this rule. It is remarkable that two closely allied species, or, in the writer's opinion, subspecies of the genus *Pinus*, i.e. *Pinus palustris* and *Pinus caribaea*, clearly differ biologically if their symbionts are considered. *P. palustris* has many more species forming mycorrhiza obligatorily confined to *Pinus*, and most stands and a fair number of individual trees if not practically all in certain regions have either *Boletinus*-, *Suillus*-, or *Gomphidius*-mycorrhiza, or at least a mycorrhizal flora consisting of such Agaricales that do not occur on or with *Pinus caribaea*. This latter pine is comparatively rarely found to be asso-

ciated with mycorrhiza-forming Agaricales, and if it is, the species are different from these observed with *Pinus palustris*. *Pinus caribaea* is associated with *Boletus griseus*, *Boletus rubricitrinus*, *Boletus rubellus* or in other words, fungi belonging to a genus where the formation of mycorrhiza with conifers is *not* a generic character, and not even a specific character as far as the species just cited are concerned. This strict differentiation may best be explained by the fact that to the slight morphological difference between these two pines there is added a somewhat stronger climatic, and a very strong ecologic factor. Most of the area of *Pinus caribaea* is situated in the tropical zone of South Florida, and the soil usually is hot and dry lime rock. Whatever the explanation, this interesting relationship tends to furnish one more argument in favor of the results of the recent investigations by De Vall.[1] For example, in Highlands Hammock State Park, *Pinus caribaea* was indicated by some authors. The analysis of the accompanying fungus flora shows that it is typical for *Pinus palustris*, not *P. caribaea*. Actually De Vall and West were able to state that the pines in question were *Pinus palustris*.

As for broad leaf trees the main mycorrhiza-bearing genus is *Quercus*. Here again I was surprised to learn how little some of the mycorrhizal fungi seem to be influenced by the variety of vegetation types in which they find themselves growing, as long as there is a suitable mycorrhiza-host. In Florida all species of *Leccinum* (group of *Boletus scaber*) are dryophilous, i.e. confined to oak; yet, *Leccinum chalybaeum* Sing. ined. was found in a flatwood under *Pinus palustris*. It was not until I found a patch of two inch high *Quercus minima* that I felt satisfied to explain the occurrence of a *Leccinum* in pine land. This little oak also grows in symbiosis with *Porphyrellus subflavidus*. Only a few feet from there, I observed several carpophores of *Tylopilus conicus*, an indubitable pine-symbiont. This shows how carefully field observations on questions of mycorrhiza must be made in order to provide information usable as a basis of future experimental studies or as a basis for taxonomic purposes, instead of being a source of perpetual confusion.

Among the vegetation types of Florida in which species of Boletineae participate, are all types of hammocks (low, mesophytic and high hammocks as well as tropical hammocks), pinelands (high pine and flatwood, and even the lime rock flats of the south) and scrub areas on white sand in sand dune regions. This enumeration is given in the order of relative importance. In open grassland (lawns, grassy places in open woods and gardens, so-called prairies and marshes, possibly some parts of the everglades), Boletineae are found exceptionally: *Clitopilus Giovanellae* and *C. scyphoides* var. *floridanus* being the only species growing outside the wooded areas, entirely independent of mycorrhiza, or as it seems even of the cooling shadow of the trees. In the scrub, under scrub oak and *Pinus*

[1] De Vall, Wilbur B. The taxonomic status of *Pinus caribaea* Mor. Proc. Fla. Acad. Sci. for 1940, **5:** 121–132. 1941.

clausa, I have observed two species of boletes, *Boletus luridellus* and *Xerocomus subilludens*, but both these species are not exclusively inhabitants of the scrub.

A phenomenon of interest for those who search for new and more convincing facts about the problem of the phylogeny of the Boletineae, has been observed in Florida: the occurrence of gastroid conditions of two now well-defined species of Boletineae, *Boletus rubellus* ssp. *caribaeus* and *Boletinus decipiens*. In the former they were sterile while in the latter they produced spores of the same kind as were produced on the pseudoangiocarpus (i.e. normal) carpophores. These parallel forms of fructification will be discussed at their proper place.

The number of species of Boletineae now known to occur in Florida is at least sixty-five. This is a remarkably high figure if the fact is kept in mind that several genera of prevalently or exclusively northern distribution such as *Gomphidius*, *Paxillus*, *Hygrophoropsis*, and *Boletinus* are represented by only one or two species each, and still the total is higher than in France, and probably higher than in the entire Caribbean area.

Some special arrangements and abbreviations to be used on the following pages need explanation. In the key, the Florida species are numbered, the numbers referring to the figures preceding the name and description of the species in this paper. The unnumbered species appearing in the keys are those studied by the author and discussed in this paper under the heading "Extralimital species." For these species the synonymy has been kept down to the most essential binomials, while for Florida species the full synonymy has been established. The keys are thought to enable the experienced reader to determine all sufficiently known species, and it is hoped that this arrangement will make the paper useful beyond the state limits of Florida, and also abroad. Under the heading "Material studied" we indicate all material that has influenced the description given. The herbaria in which the material is preserved are indicated by the abbreviations recommended by J. Lanjouw (Chron. Botan. **5** (2/3): 143–150. 1939). A special effort has been made to secure type material of the species treated, and all material collected in Florida, though the latter is scarce with the only exception of the collections preserved at the Agricultural Experiment Station of the University of Florida at Gainesville. All the descriptions and notes including the synonyms are entirely based on the author's own studies; in the very few cases where citations from other sources have been necessary, these sources have been indicated. A complete list of literature and an index of the genera and species will be given at the end of the last part of this paper which will be published at a later date. The color names in quotation marks given in the descriptions and keys are those of R. Ridgway. *Color Standards and Color Nomenclature*, Washington, D. C., 1912. Colors that cannot adequately be determined in Ridgway are cited from A. Maerz & M. Rea Paul, *Dictionary of Color*, New York, 1930, and then "M. & P." is added after the quotation marks.

ACKNOWLEDGMENTS

A fellowship of the Guggenheim Memorial Foundation has made this study possible. It enabled the writer to get a first-hand knowledge of the fungi of Florida in the field, and also to carry through a careful examination of the types of species described by W. A. Murrill at Gainesville, Florida. The author wishes to thank Dr. D. H. Linder for loan of scientific apparatus during the trip, for reading the manuscript and for the drawings on plate I of this paper. He also wishes to acknowledge his gratitude for permission to study material from other institutions than the Farlow Herbarium, namely to Dr. John N. Couch and Dr. Alma Holland Beers of the University of North Carolina, Dr. Homer D. House of New York State Museum, Dr. Fred J. Seaver, New York Botanical Garden, Dr. Walter H. Snell, Brown University, Mr. E. West and Dr. W. A. Murrill, University of Florida. It is a pleasure to acknowledge the kind and efficient help the author had from all botanists he met in Florida. He wants to extend his thanks for innumerable courtesies to Erdman West, University of Florida, for laboratory space and valuable advice to Dr. Williams, University of Miami, for office and transportation facilities to Mr. Altvater, Highlands Hammock State Park, now in the Armed Services, for determination of hosts to Dr. Buswell, University of Miami, and Miss Lillian Arnold, University of Florida. The writer is also thankful for the help in planning the trip offered by Dr. E. D. Merrill, Harvard University, and Dr. D. Fairchild, Coconut Grove, Fla. Their competence in everything connected with plant life in Florida made it possible for the author to be at the right time at the right place, probably the most important thing for anyone who wants to collect in Florida. It is impossible to mention all the names of those who have turned in specimens of fungi, but their contributions are highly appreciated.

SUBORDER BOLETINEAE

(Opat. 1836 ut fam.) Pilát 1926, em. Sing. 1936.

KEY TO THE FAMILIES

A. Spores never pale pink, mostly ornamented, or nearly black to black, or "warm sepia" to "Sudan brown" or "hazel" in print, or extremely long (most of the spores of a print over 20 μ in length), or with thick (thicker than 1 μ) wall applanate or provided with a germinative pore at the apex; hymenophore ordinarily (in Florida always) tubulose; clamp connections none. *Strobilomycetaceae*

A. Spores either pale pink, or smooth (constantly and persistently so), if nearly or distinctly black, and if larger than 20 μ, the hymenophore is lamellate; if thick walled, the hymenophore usually lamellate and/or clamps present; germinative pore none; hymenophore either lamellate or tubulose, also merulioid, or showing some configuration intermediate between lamellae and tubes; clamp connections absent or present.

B. Hymenophore tubulose, rarely merulioid or (in one species) lamellate, and then the surface of the pileus turning deep blue or greenish blue with ammonia. *Boletaceae*

B. Hymenophore lamellate. Pileus not turning deep blue nor greenish blue with ammonia.

C. Spores evenly rounded, not angular when seen from one end, nor furrowed; carpophore usually well pigmented, mostly strongly reacting with NH_3, KOH, $FeSO_4$, and other reagents; lamellae sometimes very thick and distant; clamp connections absent or present; cystidia absent or present.

D. Clamp connections absent; spore print black or nearly so; spores clearly elongate. *Gomphidiaceae*

D. Clamp connections present; spore print brownish to "chamois," or creamy white; spores not elongate. *Paxillaceae*

C. Spores not evenly rounded but angular when seen from one end, and often furrowed longitudinally; pigment none, or grey, not reacting strongly with NH_3, KOH, $FeSO_4$; lamellae not thick, not distant; clamp connections none; cystidia none. *Jugasporaceae*

STROBILOMYCETACEAE Gilb. 1931 (as Strobilomyceteae)

Characters of the family: pileus squamose to squarrose, or squamulose to glabrous, viscid, or not viscid, small to large, the margin frequently projecting; hymenophore tubulose, rarely lamellate, tubes usually comparatively long halfway between the margin and the stipe, strongly convex beneath, depressed to adnate, pores medium wide to rather wide when mature, discolorous or more frequently concolorous with the tubes: whitish to gray, or whitish to pale grayish cream color, becoming vinaceous pink to sordid purplish, or yellow, golden yellow, the pores sometimes orange to red, at last olivaceous or yellowish brown, sometimes becoming black or red or blue on pressure; spore print black or nearly so, or, if not black, a very deep brown with an olive tinge, or deep porphyry brown to reddish brown ("warm sepia," "hazel," "Sudan brown"), rarely (in some olive brown colors) approaching spore colors observed in Boletaceae, and then the spores differing microscopically from the latter; spores richly colored when quite mature, fuscous to deep succineous-melleous with darker ornamentations, more rarely persistently smooth, and then either remarkable for their unique size (20–30 μ), or for their comparatively thick walls (more than 1 μ), the endosporium usually interrupted at the apex forming an incomplete germinative pore, or the apex applanate as in *Ganoderma*, or even more acuminate than it is in the Boletaceae, outline globose, subglobose, short-ellipsoid, fusoid, rarely ovoid-fusoid; basidia and cystidia comparatively voluminous, mostly more so than in species with equally large spores in the Boletaceae; trama of the tube walls pronouncedly bilateral in youth, hyphae without clamp connections; stipe usually approximately cylindrical and comparatively long and slender, smooth or ornamented with woolly or fibrillose scales, or with shallow to conspicuously projecting alveolate networks which in the most typical cases are waxy-slippery and bearing a hymenium; veil often present and then woolly or membranaceous, sometimes viscid, either fugacious, or persistent as an annulus on the stipe or as an appendiculate margin on the pileus, or both, never entirely glutinous, not yellow-pulverulent; stipe always destitute of glandulae. Habitat: on earth, more

rarely on the base of trees, or on decaying wood, most species preferring warmer climates, only few species reaching Canada, and only two species known from Europe and adjacent regions.

When any local flora is analyzed, and the representatives of the Strobilomycetaceae compared with each other and with the Boletaceae, it usually so happens that they are not easily recognized as a homogeneous group. In Europe, the spores of the two species found there are very different, especially when studied superficially, and the classification of the boletes according to the macroscopical characters of the pileus and the stipe that had been usual in both the American and European literature up to very recently, deepened the impression that the North American Strobilomycetaceae were widely different macroscopically, and only the "incidental" characters of the spores simulated an allegedly non-existing relationship. Even in South Carolina with its comparatively rich flora, Coker and Beers (The Boletaceae of North Carolina, p. 74. 1943) offer the opinion that "to attempt to segregate them as a unified group would seem to us unadvisable." Strangely enough, the strobilomycetaceous species of *Boletus sensu lato* in the same book are arranged much like a unified group. They are treated in the following order: *B. chrysenteron sensu* Coker & Beers, *B. sordidus*, *B. chrysenteroides*, *B. ananas*, *B. Russellii*, *B. betula*; — missing only *B. gracilis* (with the spores erroneously described as smooth), *B. projectellus* (with actually smooth spores), and *S. floccopus* (already transferred to *Strobilomyces*). If all characters and all species known (including those from Asia and Africa) are considered, there is no doubt that the Strobilomycetaceae constitute a natural group though related to the Boletaceae, but not showing clear kinship with any genus of the latter, differing not only in the finer structural characters of the spores, but also in their color. They also show a combination of macroscopical characters that makes it possible for the experienced collector to foretell the spore characters in a general way. The relatively large size of the basidia and cystidia in most species is an additional criterium. The astonishing similarity of the chemical characters in *Porphyrellus pseudoscaber* (Secr.) Sing. and *Strobilomyces floccopus* convinced the author still more that the two species and genera are more closely related than formerly has been suspected. Nevertheless the gaps between some of the species known to belong to the Strobilomycetaceae may seem rather wide, and some striking types may, rightly or wrongly, cause the taxonomist to erect several separate genera. That is why, indeed, a number of genera already have been proposed for them: *Strobilomyces* Berk. for *S. floccopus* and allied species, *Porphyrellus* for *B. pseudoscaber*, *Boletogaster* for a form near *B. jalapensis*, *Frostiella* for *B. Russellii* and *B. betula*, and *Boletellus* for *B. ananas*.

However, if all the groups and species from all over the world are taken into consideration, the gaps between them do not appear to be so striking, and one has difficulty in distributing the species in genera or sections rather than in finding connecting links between them.

In Gilbert's scheme the Strobilomycetaceae are divided in two genera

according to the color of the pores which are whitish to gray in *Strobilomyces* and yellow in *Boletellus*. In *Leccinum* where a similar situation exists, this character has certainly no more than sectional value, and neither in *Leccinum* nor in the Strobilomycetaceae is it accompanied by any one correlated character. As a matter of fact, the squamose condition of the pileus in *Strobilomyces* is found in the type species of *Boletellus* as well as in some other species and the reticulate short spores known in *S. floccopus* are also found in *Boletellus retisporus*, a species characterized by yellow pores. Thus, the characters on which Berkeley based his genus *Strobilomyces* are not confined to this genus. On the other hand two African species, *S. costatisporus* and *S. pterosporus*, have all the essential characters of *S. floccopus* but short ellipsoid spores with the same longitudinal wing-like ridges as known in *Boletellus singaporensis* or *B. Linderi* where the pores are yellow or red and the veil of a quite different structure.

Likewise the color of the spore print, often useful in the classification of the Boletaceae, cannot be used to the same extent in the Strobilomycetaceae because of the uncorrelated occurrence of some shades and tinges. The spores of *Strobilomyces floccopus* and *Boletellus ananas* are practically black in print though very different in ornamentation and shape. *Porphyrosporus subflavidus* and *Boletellus betula*, otherwise similar, have the hymenophore, including the pores, and the spore print differently colored. *Porphyrellus subflavidus* and *P. pseudoscaber* though having the same color of the spore print, are chemically different. The species, intermediate between these, *Porphyrellus gracilis*, has the spore print of a shade differing from both *P. subflavidus* and *P. pseudoscaber*.

The situation is not even as simple as it seemed at first, since further studies revealed that there are not merely white, gray, and yellow-pored species, as Gilbert thought, but there also are species with initially pallid cream-colored pores (e.g. *Porphyrellus tristis*), species with white pores that become vinaceous pink (*Porphyrellus gracilis, P. malaccensis, P. subflavidus*) and species with discolorous pores that are tinged orange to red (*Boletellus Linderi, B. pictiformis*).

The spores are not only of two types, as was assumed formerly, but there is a third type, usually described as punctate or warty; in this case cylindric spines are imbedded in the exosporium, protrude slightly or scarcely, and when they are seen from above, they are described as punctate (*Boletellus betula*), but when they are seen in an optical section showing the outline, the spores are mostly described as smooth (*Porphyrellus gracilis, P. subflavidus*), or warty-rough (*Porphyrellus malaccensis*). In some cases species with the essential macro- and microcharacters of a related rough-spored strobilomycetaceous species, have not seemingly but actually smooth spores. These smooth spores are easily recognized as strobilomycetaceous by their size, color, or thickness of the walls, or by the shape of the apex of the spore, and the combined remaining characters put these forms in the neighborhood of some indubitable representative of the Strobilomycetaceae rather than of the Boletaceae where most smooth-spored

species belong. If it could be doubted hitherto that there are any smooth-spored species actually related to some species of Strobilomycetaceae, there is no longer room for doubt in view of the fact that both smooth and perforated spores are found in a single preparation of some specimens of *Porphyrellus pseudoscaber* and *Strobilomyces velutipes*. In both cases the majority of the spores is smooth even when mature, and the minority is ornamented.

The above-cited facts show that the Strobilomycetaceae are a homogeneous and probably natural family within the Boletineae, and have to be treated as such. The difficulty in achieving a satisfactory division of the family into genera could be avoided by recognizing only one genus for all tube-bearing Strobilomycetaceae. However, this would mean only a delay in solving the problem, for poor genera will never constitute good sub-genera, and a single genus for all species involved would not match well with the generic conception now generally adopted in the Boletineae.

As the author thinks now, the difficulty will be solved most naturally by adopting a third genus for the tube-bearing Strobilomycetaceae, besides *Strobilomyces* and *Boletellus*. This genus has to take care of the species with elongate, smooth or perforated spores that are somehow reddish brown without an olivaceous tinge. Since it would therefore, among others, embrace the *Porphyrellus pseudoscaber*-complex on which the genus *Porphyrellus* has been based, it would not be necessary to propose a new generic name, but merely transfer *Porphyrellus* from the Boletaceae to the Strobilomycetaceae. Gilbert, not satisfied with the naming of a genus to replace Bataille's homonym *Phaeoporus*, transferred several species to *Porphyrellus*, American species which he did not know personally. Here started a confusion which could only be straightened out by studies in America using fresh spore prints and good fresh and authentic dried material. It turned out that *Boletus alboater* Schw. and *Boletus nigrellus* Peck, synonyms by the way, are not related to *Porphyrosporus pseudoscaber*, as claimed by Gilbert, but belong in a section of *Tylopilus* Karst. (Boletaceae), not represented in Europe. This explains why Gilbert, not knowing any species of this section, and not having recognized the genus *Tylopilus* at all, misplaced the two American species in his *Porphyrellus*. *Porphyrellus* differs from the above-mentioned section of *Tylopilus* in having more strongly pigmented spores with a different color in print, and with thicker walls and either acuminate or truncate apex. It also differs in having the pores much wider in age than they are in *Tylopilus*, and finally, their hymenial elements are decidedly more voluminous, especially in proportion to the spore size. The chemical reactions also support this distinction. Though both in *Tylopilus* and in *Porphyrellus* there are species with a pileus covered by a trichodermium, the structure of this layer on the stipe is not quite identical, and the trama of the dissepiments of the hymenophore becomes subregular in *Porphyrellus* in a much earlier stage than in *Tylopilus*. The occurrence of spores with imbedded warts in some forms of *Porphyrellus pseudoscaber*

emphasizes the difference between the type species of *Porphyrellus* and the genus *Tylopilus* with its constantly smooth spores.

Porphyrellus pseudoscaber is closer to *Strobilomyces* than it is to *Tylopilus*. This is shown by the occasional presence of spores with imbedded warts as in *Strobilomyces velutipes*, by the above-mentioned similarity of the chemical characters of *P. pseudoscaber* and *S. floccopus*, the intensely colored spore wall in both *Porphyrellus* and *Strobilomyces* and the rather large size of the basidia when compared with spore size in both these genera. It is therefore surprising to see that Fries, who did not know any of these characters, by mere intuition treated *Boletus porphyrosporus* (i.e. *Porphyrellus pseudoscaber*) and *Boletus strobilaceus* (i.e. *Strobilomyces floccopus*) within one and the same subgroup, the section *Favosi* Fr. Bataille had *Eriocorys strobilaceus* (*S. floccopus*) and *Phaeoporus porphyrosporus* (*P. pseudoscaber*) in the same series *Porphyrospori* Bat.

There are now about forty-five species known to belong or probably belonging in the Strobilomycetaceae, of which roughly two thirds are sufficiently studied. Only about one quarter of the total is not prevalently or exclusively tropical or subtropical. Eight species and varieties have been observed in Florida. Three of these are endemic and have not thus far been found except in Florida. This puts Florida among the regions richest in strobilomycetaceous forms: the southern part of North America, the West African tropics, and the Austral-Asiatic tropics.

KEY TO THE GENERA AND SECTIONS

A. Hymenophore, at least in its larger part, distinctly tubulose.

B. Spores globose to short-ellipsoid; hymenophore white to gray at first, becoming darker in age; stipe not waxy-costate-lacunose; pileus and stipe either warty, or woolly, or spinose-squarrose. Gen. *Strobilomyces* Berk.

C. Spores smooth, at least a considerable percentage of them, or beset with warts and short ribs, or either of these, imbedded in the exosporium, or with more or less imbedded to subfree reticulate ridges, forming a complete network on the spores. Sect. *Genuini* Sing.

C. Spores with longitudinal wing-like thin ridges running from the hilar end toward the very apex of the spore where they abruptly stop. Sect. *Pterospori* Sing.

B. Fungi not combining the characters outlined above, i.e. spores either distinctly elongate (Q larger than 1.5), or hymenophore not white, nor gray at first; if the pileus is adorned by projecting warts, floccons, or erect spines, the hymenophore is yellow to red, and the stipe is not strongly floccose, or a veil is entirely wanting, or both.

D. Tubes and pores of the young carpophores white to pale grayish cream color, becoming light pinkish vinaceous or sordid gray to porphyry brown with a grayish tinge when quite mature; spores with short cylindric warts or with slender spines perforating the exosporium, making the spores appear punctate when their upper surface is focussed upon under an oil immersion lens; in some cases the vast majority, or even all spores are virtually smooth; spore print reddish brown (varying from "warm sepia" to "Sudan brown" or "hazel") without any olivaceous tinge (at least in the species studied in this regard). Gen. *Porphyrellus* Gilb. em.

E. Pileus sordid or at least very dull-colored, gray or umber. Context strongly reacting with KOH, NH_4OH, $FeSO_4$, etc.; stipe not reticulate, its trichodermium usually forming a distinct velutinous layer.
Sect. *Tristes* Sing.

E. Pileus brighter-colored: yellowish brown, light yellow to occasionally white, chestnut, or some other shade of reddish brown; context either weakly or not at all reacting with KOH, NH_4OH, $FeSO_4$, etc.; stipe at least finely or even obscurely reticulate, or partly so, or deeply waxy-costate-lacunose. Sect. *Graciles* Sing.

D. Tubes yellow in youth, becoming melleous or brownish melleous, or olivaceous with age; spores with an ornamentation as described above, or smooth, or — most frequently — longitudinally winged to striately ribbed, in one species reticulate as in *Strobilomyces floccopus*; spore print deep brown with an olivaceous tinge to blackish, not reddish when fresh.
Gen. *Boletellus* Murr. em.

F. Pileus pink, purple, or carmine, but frequently at least partly expallent, not viscid; spores ornamented with longitudinal wing-like ridges or striate with narrow ribs or veins from the hilar end to the tip, never smooth, nor otherwise ornamented; length of the majority of the spores when fully mature more than 17 μ. Sect. *Ananae* Sing.

F. Pileus rarely showing the above colors, and then either viscid, or (and) spores smooth, or differently ornamented, or shorter.

G. Spores either smooth and very large (length 20 μ and above), or short (around 12 μ) and reticulate; apex of the stipe with a rather indistinct to very distinct reticulation, or most of the stipe with longitudinal veins that anastomose, but never entirely smooth, nor with waxy-costate-lacunose surface in the species known.

H. Spores strongly elongate, smooth; margin decidedly projecting.
Sect. *Mirabiles* Sing.

H. Spores short, reticulate; margin not distinctly projecting.
Sect. *Retispori* Sing.

G. Spores either smaller than 19.5 μ if smooth, or, if they are not smooth, never reticulate; stipe either waxy-costate-lacunose, or smooth, or woolly-shaggy-subreticulate.

I. Neither pileus nor stipe viscid when wet, and veil, if present, not viscid. Sect. *Chrysenteroidei* Sing.

I. Either pileus or stipe or veil (if present) viscid, or all three viscid.

K. Spores with longitudinal wing-like ridges.

L. Stipe smooth or almost so, sometimes annulate; pileus not velutinous-tomentose. Sect. *Ixocephali* Sing.

L. Stipe waxy-costate-lacunose, the thin lamellose ribs very high, limiting deep honeycombs where rain-water remains stored; pileus tomentose (at least in the American species), and not distinctly (if at all) viscid. Sect. *Dictyopodes* Sing.

K. Spores with short cylindric warts which for the most part are imbedded in the exosporium, and when the upper surface of the spores is focussed upon, it appears punctate.
Sect. *Allospori* Sing.

A. Hymenophore lamellate. Gen. *Phyllobolites* Sing.

Strobilomyces Berk., Decades of Fungi 32–33. Hook. Journ. Bot. **3:** 77. 1851.

Eriocorys Quél., Ench. Fung., p. 163. 1886.

Characters of the genus: see key (p. 106). Type species *Strobilomyces strobilaceus* (Scop. ex Fr.) Berk., a synonym of *S. floccopus* (Vahl in Fl. Dan. ex Fr.) Sacc.

Sect. **Genuini** Sing. sect. nov.

Sporis levibus, perforato-verrucosis, cristulatis, reticulatisve.

Characters of the section: see key (p. 106) and the above Latin diagnosis.

KEY TO THE SPECIES

A. Spores smooth or with short perforating warts in the episporium, making the spores appear punctate when seen from above. *S. velutipes*

A. Spores not smooth (only a small minority occasionally smooth, and many immature spores smooth, but then the ornamented ones not as above), and not punctate when seen from above.

B. Spores with short ridges and occasional isolated warts, incompletely connected with each other to form a fragmentary network; pileus with a covering of rigid, very acute, erect, thin spines or pyramids which often are cristate, or fimbriate, or fasciculate, the single ones frequently applanate in one direction, and never with a base wider than 1 mm. along its smallest diameter, and 2 mm. along its largest diameter in dried condition. 1. *S. confusus*

B. Spores with a complete network; pileus with less rigid and more woolly scales with a larger basal diameter when dried, or with the same kind of warts as described above (the scales rather smaller than those), but at the same time with merely squamulose marginal half.

C. Warts or spines or scales of the pileus larger than 2 x 1 mm. at their base, and not very rigid. 2. *S. floccopus*

C. Warts acute, and their base smaller than 2 x 1 mm., rigid, confined to the disk; the marginal half merely squamulose. *S. nigricans*

DESCRIPTIONS OF THE SPECIES OBSERVED IN FLORIDA

1. **Strobilomyces confusus** Sing. spec. nov.

PLATE I, FIG. 1

Pileo atro, spinulis erectis, rigidis, acutissimis, subinde fimbriatis vel cristatis obtecto, spinulis densioribus in centro, margine velo appendiculato, sed haud distincte nec persistenter lanato, sicco, 40–85 mm. lato; tubulis porisque albido-griseolis vel griseis, siccando nigrescentibus, cinnamomeo-maculatis ubi tacti sunt, at maculis eis gradatim nigrescentibus, 10 mm. longis vel longioribus, plerumque subdepressis ad stipitem; sporis in cumulo nigris, cristulatis et incomplete reticulatis, 10.5–12.5 x 9.7–10.2 μ; basidiis 37–48 x 11–13.5 μ; cystidiis clavatis, dein fusoideo-mucronatis vel vesiculosis apice ampullaceo, fuscescentibus, (22)–34–61 x 7.5–26.5 μ; stipite griseo, ad apicem reticulato, lanato-lacerato infra zonam reticulatam, plerumque attenuato basin versus, ad ipsam basin saepe incrassato, solido, 42–78 x 10–20 mm.; velo pro ratione sparso; carne pilei alba, celerrime rubescente, in stipite alba, autoxydatione et rubente et nigrescente; odore haud notabili. Habitatio: in pratulis umbrosis, in hortis, in pinetis mixtis prope *Quercus minimas*, in dumetis frondosis sub *Quercubus laurifoliis* et *Q. virginianis*. Secundum litus Atlanticum Septentrionale occidentemque versus usque ad Ohio et Tennessee.

Pileus between fuscous black and black, with thin but rigid, not woolly, very acute, erect spines which are denser toward the center, and often cristate, fimbriate, or fasciculate, also not rarely compressed, the basal diameter not over 2 x 1 mm. in dried material, occasionally the spines obliterated or evanescent, and then the pileus appearing areolate-squamose and not much different from similar forms of *S. floccopus*, never viscid, not woolly, or at least not strongly and persistently so because of the greater coherence and scarcity of the veil which often hangs in small patches from the margin, surface convex, the center flattened when old, 30–85 mm. broad. — *Hymenophore* whitish-gray to gray, becoming blackish even if carefully dried, becoming spotted with "cinnamon" where touched in fresh condition, these cinnamon places then changing to deep chocolate and finally black; tubes 10–18 mm. long, very slightly depressed around the stipe, but also adnate-subdecurrent in smaller, and decidedly depressed in larger individuals; pores medium wide, about as in *S. floccopus*; *spore print* black. — *Stipe* gray, reticulate at the apex above the annulus (or remnants of the veil), shaggy-woolly below it, solid, tapering downward or more rarely equal, the base often somewhat thickened, 42–78 x 10–20 mm.; veil not abundant, and annulus not persistent. — *Context* whitish, quickly reddening in the pileus reaching a deep carrot color except for a narrow zone under the cuticle, the context of the stipe white, reddening and blackening simultaneously on exposure; odor not remarkable.

Spores short-ellipsoid to globose, fuscous, with very fragmentary dense network, or merely echinate, cristulate with occasionally connected spines, the ornamentation 0.3–1.7 μ high but usually partly or almost entirely imbedded in the much paler exosporium, wall rather thick with an incomplete or complete germinative pore, 10.5–12.5 x 9.7–10.2 μ; basidia (3)–4-spored, 37–48 x 11–13.5 μ; *cystidia* clavate, then becoming fusoid-mucronate and brown, also sometimes clavate-mucronate, or vesiculose with ampullaceous apex (neck), (22)–34–61 x 7.5–26.5 μ; *trama* of the dissepiments of the hymenophore with a colored, denser mediostratum and a paler lateral stratum of divergent hyphae, hyphae without clamp-connections; *cuticle* (tips of the warts) of strands of parallel hyphae which are brown, 17.5–63 x 3–20 μ, with transverse outgrowths, horns, buttons etc., the terminal members sometimes clavate.

Chemical reactions: not separately studied (hardly much different from those of *S. floccopus*).

Habitat: On shaded grass lawns in gardens, in mixed pine woods (e.g. woods of *Pinus palustris* and *Quercus minima*), and also in high and mesophytic hammocks under hardwood trees (e.g. *Quercus laurifolia* and *Q. virginiana*). Summer.

Distribution: From Massachusetts west to Ohio and Tennessee south to central Florida. In Florida not rare though not quite so common as *S. floccopus* which seems to go farther north as well as farther south.

Material studied: **Fla.:** Eustis, Lake Co., Oct. 1897, *Thaxter 6177* (immature) (FH); Flatwood east of Gainesville, Alachua Co., July 1943, *Singer F 2782*, **type** (FH); other

collections in and near Gainesville, *Singer F 2766 I, F 2531, F 2647*, **co-types** (FH). **Mass.** Wood's Hole, *Farlow* (FH); Plymouth, Aug. 1889, *Farlow* (FH). — **Pa.:** Martic Forge, Marticville, on humus in chestnut orchard, Aug. 1910, *J. F. Collins* (FH). — **Ohio:** Symmes, Hamilton Co., July 1935, *W. B. Cooke 41452.* (FLAS, FH). — **Tenn.:** Cades Cove, Blount Co., July 1938, *J. P. Porter*, mixed collection (FH).

This species, so strikingly different microscopically, has never been distinguished from *S. floccopus* (*S. strobilaceus*) in this country. Both these species apparently require about the same conditions for their development since many collections in the herbaria are mixed. Once the distinguishing features are understood, they are so pronounced that it is possible to foretell what type of spores a certain dried specimen will have, and vice versa. Allowance, however, should be made for specimens which under certain conditions, do not develop or preserve the characteristic acute spines on the pileus. These forms are, fortunately, rather rare. On the other hand, the ornamentation of the spores is quite constant. Among published photographs Krieger, *Popular Guide . . .* , p. 444, *fig. 125*, phot. Cummins, may well belong here, while Atkinson, *Mushrooms*, *fig. 172–174* certainly is *S. floccopus*.

2. **Strobilomyces floccopus** (Vahl in Fl. Dan. ex Fr.) Karst., Bidr. Finl. Nat. Folk **37:** 16. 1882.

Boletus floccopus Vahl *in* Fl. Dan. *ex* Fr., Syst. Myc. **1:** 292. 1821; Persoon, Myc. Eur. **2:** 144. 1825. *non* Rostkov.
Boletus gossypinus Pers., Myc. Eur. **2:** 144. 1825.
Boletus squarrosus Pers., Myc. Eur. **2:** 145. 1825.
Boletus cinereus Pers., Myc. Eur. **2:** 144. 1825.
Boletus strobilaceus Scop. *ex* Fr., Elench. **1:** 127. 1828.
Boletus stygius Wallr., Comp. Fl. Germ. Sect. II, **4:** 608. 1833.
Boletus strobiloides Krombh., Nat. Abb. **10:** 21. *pl. 74, fig. 12–13.* 1846.
Strobilomyces strobilaceus Berk., Dec. Fung. 32–33, Hook. Journ. Bot. **3:** 77. 1851; Outl. Brit. Fungol., p. 236. 1860.
Boletus lepiota Vent., Micet. Agr. Bresc., p. 37. *pl. 43.* 1863.
Boletus hydriensis (Hacquet ut *Clathrus ex*) W. Voss, Oesterr. Bot. Zeitschr. **32:** 40. 1882.
Eriocorys strobilacea Quél., Enchir., p. 163. 1886.
Eriocorys strobilacea var. floccopus Bat. Bolets, p. 11. 1908.

PLATE I, FIG. 2.

Pileus between "mummy brown" and black, or about "sepia," or more gray all over or particularly near the margin, the rimosely diffracted portions of the pileus between the scales either much paler, almost white, or even darker (black) if the discoloration of the context has reached the surface, paler on the margin because of the abundance there of the woolly gray or white or sordid veil that hangs in soft patches from the margin and initially continues into the corresponding layer of the stipe, the scales often with blackened tips, softer than in *S. confusus*, entirely covering the surface of the pileus, not viscid, large (larger than 2 x 1 mm. at their base in dried specimens), erect and pyramidal, often curved, or imbricate and more or less appressed, hardly denser toward the center of the pileus, surface pulvinate, finally flattened, 44–155 mm. broad. — *Hymenophore* gray, or white, be-

coming gray, the pores concolorous but reddening or blackening on pressure, or reddening and subsequently blackening, angular, usually lamellose around the stipe when mature, medium to wide, tubes 12–14 mm. long or occasionally longer, adnate to somewhat decurrent, or slightly depressed around the stipe; *spore print* black. — *Stipe* gray to concolorous with the pileus, and with gray or white or sordid abundant veil at least in the middle portion of the stipe where it forms a thick woolly covering, sometimes several subparallel belts up to a usually amorphous annulus, the apex sub-glabrous, striate with longitudinal veins running down from the walls of the tubes, the base tomentose, solid, subcylindric, or tapering upward, or downward, 50–125 x 12–21 mm.; veil sometimes consisting of two distinct layers, the outer one more colored. — *Context* white or whitish in the pileus, either merely blackening, or reddening while blackening, or reddening and then blackening, these discolorations sometimes blending into a dirty pink or fuliginous-lilac shades, the same colors and color changes taking place in the stipe though the discolorations there quite frequently in contrast with the context of the pileus, rather dry, especially in the stipe when compared with some other species of Strobilomycetaceae and especially with Boletaceae, and slightly tougher than these; odor not remarkable; taste mild, nutty.

Spores 9.7–15 x 8.5–12 μ, covered entirely by a constantly complete network that raises 0.3–1.7 μ high, but frequently almost entirely imbedded, the wall rather thick, with a more or less distinct germinative pore, asymmetrical, buff brown with deeper brown ornamentation; *basidia* 30–58 x (7.5)–10–18 μ, 4-spored; *cystidia* numerous, 17–90 x 8–26 μ, clavate, very frequently mucronate-apiculate, hyaline, occasionally containing a brown drop when very young, later brown throughout, few cystidia more lanceolate or fusoid, but never really acute above; *trama* of the dissepiments of the tubes consisting of a denser, brownish mediostratum, and a looser, hyaline divergent lateral stratum, hyphae of the mediostratum cylindric (few vesiculose), parallel-subinterwoven, clampless; *spines of the pileus* made up of strands of parallel hyphae with clampless septa at a distance of (20)–40–88 μ, cylindric or slightly narrowed at the septa, brown, the terminal members often slightly attenuate toward the apex, but always rounded, 7–17.5 μ thick.

Chemical reactions. **KOH** on surface of pileus brown; on context red then usually becoming brown or brownish, the red reaction usually bright and distinct, rarely dull because of the beginning blackening due to autoxydation; **NH_4OH** on context ochraceous, or (in Dade Co. specimens) nil; **$FeSO_4$** bluish gray, bluish-greenish-gray, or glaucous; **HNO_4** on context yellow.

Habitat: In mixed woods, more frequently under frondose trees than under conifers, in Florida frequently on well-shaded lawns, in gardens, also in mesophytic, high, and tropical hammocks, usually under oaks. Summer and fall.

Distribution: With certainty from Spain to the Caucasus, and from Sweden to North Africa in the Old World, and from tropical Florida to

Canada, apparently west to the Pacific Coast, also observed in eastern Asia (e.g. Japan); its occurrence near the Equator and southward is not quite certain. In Florida probably in all counties.

Material studied: **Fla.:** Dade Co., Fairchild Tropical Garden under *Quercus virginiana* Sept. 1942, *Singer F 750* (FH); Brickell's Hammock under *Q. virginiana*, November 1942, *Singer F 931* (FH); Alachua Co., numerous collections in 1943, *Singer F 2766, 2647a, 2194, 2752, 2020a, 2020b, 2606, 2899, 2532, 2736/II* (all FH), some *Murrill* (FLAS). — **Canada:** Petawawa Forest Experiment Sta. *C. G. Ridley 9531* (FH). — **Me.:** Kittery Point, Aug. 1897, *Thaxter* (FH) and Aug. 1895, *Thaxter 1559* (FH). — **Mass.:** Milton, Aug. 1896, *H. Webster* (FH); Plymouth, *Farlow* (FH); *Hornblower*, det. D. H. Linder (FH); Wakefield, *Singer* (FH); Harvard, *Singer* (FH). — **Pa.:** Center Co. State College, Sept. 1933, *W. L. White 1284* (FH). — **Ga.:** vicinity of Tallulah Falls, July–Sept. 1901, *A. B. Seymour*, det. W. G. Farlow (FH). — **Iowa:** Iowa City, *G. W. Newton*, det. A. P. Morgan (FH). — **Mich.:** Whitmore Lake, July 1921, *L. E. Wehmeyer* (FH). — **Tenn.:** Cades Cove, Blount Co., July 1938, mixed with *S. confusus*, *J. B. Porter* (FH). — **Austria:** Rekawinkel, Niederoesterreich, *Hoehnel* (FH); — **Germany:** Chiemsee, southern Bavaria, Aug. 1922, *Singer*; — **France:** several collections of fresh material; — **Spain:** Catalonia, La Sellera, *Codina*, det. Singer, Aug. 1934 (BC); — **Caucasian Mts.:** Swanetia, Khä, under *Corylus ?colurna*, Aug. 1929, *Singer* (W); Filimonov Range, under *Fagus orientalis* and *Abies Nordmaniana* on decayed wood, Aug. 1935, *Vasilieva* (LE, KAZ.); also other Caucasian localities, once on rhizomata of *Struthiopteris germanica*, etc.

There is no doubt that this species can easily be separated from all other species of this group. Unfortunately, the well-introduced and generally accepted name *S. strobilaceus* is illegal since Fries in his *Systema Mycologicum* used a name *ex Flora Danica*, but later has both species side by side, with the unexpectedly jovial comment (translated): "in my sense not enough different, but I figure, I have to concede a bit to others also." Had it been possible to emend this and similar situations by replacing Fries's *Systema* by the *Epicrisis* as the nomenclatorial starting point, while there was still time (see Revue de Mycologie **3:** 39. 1938), the usual name could have been saved. Since, mostly because of the war, no steps have been taken, I do not want to make my own rules in monographic papers, but I think it is the general desire of all taxonomists that now, since it is too late for drastic changes, no belated halfway measures may punish those who have followed the rules strictly. Many important monographic papers have appeared since my suggestion appeared, and it is to be hoped that their nomenclature, not the nomenclature of older and now less important papers be preserved. As for *S. strobilaceus*, however, there may still be a faint chance to preserve this name for a valid species, if future careful studies should prove that *S. floccopus* and *S. strobilaceus* represent two independent species. I have tried to distinguish between a form with reddening flesh and another one with blackening context, and at first it seemed that a slight difference in the KOH reaction runs parallel with this differentiation; it also appeared that there was a correlation between these characters and the more sepia or more gray color of the pileus, and the shape of the scales; but on the other hand, there seemed to be at least one more form with a different combination of characters (the form from Dade Co.). Intermedi-

ate forms, in the long run, made me abandon my initial scheme. As I see now, these intermediate forms may at least partly be explained by the fact that many of them eventually turned out to be *S. confusus*, but even after their elimination, the distinction between the typical *S. floccopus* and *S. strobilaceus* is not quite clear, and it would be unwise to identify these forms as observed by us with European species described as poorly as *Boletus floccopus* in Fries's *Systema*. Unless further accurate data on a large number of specimens in Europe as well as in America prove the opposite to be true, I treat *S. floccopus* as a variable but homogeneous species.

S. floccopus is considered, by mycophagists, as edible though mediocre in quality.

EXTRALIMITAL SPECIES

Strobilomyces velutipes Cooke & Mass., Grevillea **18:** 5. 1889.

PLATE I, FIG. 6.

Described from Australia, it is said to be "resembling *S. strobilaceus* and *S. nigricans*, but entirely different in the spores." I have studied a fragment of the type (NY). This species actually differs from *S. floccopus* and *S. nigricans* in having spores which are either smooth, or differently ornamented, and smaller than in the other species. I found them short-ellipsoid to subglobose, fuscous, thick-walled, more often without any ornamentation than with it, and, in the latter case faintly rough in the outline of the main wall which is often surrounded by an indistinct hyaline perisporium, 8.5–10.5 x 7–7.7 μ; the ornamentation consists of warts which frequently are so dense as to form an interrupted partial reticulation, the reticulation at least in its lower part imbedded in the main wall much as in *Porphyrellus gracilis* but less conspicuously so because of the low ornamentation and the slight difference in color between the warts and the remaining portions of the wall (ornamentation rarely reaching 0.7μ in height); basidia 24–30 x 10–10.5 μ, clavate-subfusiform and short, 2–3–4-spored, often aborted and cystidia-like; cystidia fusoid and usually apiculate at the apex; hyphae without clamp connections. *S. indicus* Lloyd (Mycol. Notes **7:** 1331. 1924) is, according to the data given by its author, the same species.

S. velutipes demonstrates the transition from smooth to ornamented spores. It does not demand too much imagination to draw a connecting line between the smooth short spores of this species and the elongate smooth spores of *Porphyrellus*, both with a varying percentage of perforately warted spores intermixed in a single preparation, with the same chemical characters (if it can be supposed that the reactions of *S. velutipes* are essentially the same as in *S. floccopus*), the same dull colors, the same habit, etc. The elongate spores, naturally, have the wall slightly thinner and lighter colored. For those who are used to phylogenetic thinking, there remains little doubt that the genus *Porphyrellus* has derived from such forms as *S. velutipes*.

Strobilomyces nigricans Berk., Dec. Fung., Lond. Journ. Bot. **4:** 139. *pl. 6.* 1852.

Described from Khassya, British India, it was rediscovered by Patouillard in one of the collections sent to him from Indo-China. In his Herbarium, now preserved at the Farlow Herbarium, the dried specimens described by him (Bull. Soc. Myc. Fr. **39:** 54. 1923) are found in good condition though still labeled with an herbarium name since Patouillard initially thought this species was new. The acute warts of the center of the pileus remind one of *S. confusus*, but *S. nigricans* is smaller, at least the Indo-Chinese collection, and the warts are denser. When compared side by side with either of the American species, it seemed to be different. The spores were found to be identical with these of *S. floccopus:* dark fuscous, thick-walled, short-ellipsoid to subglobose or globose, with a complete network of arcuate ridges and veins which are up to 0.5 μ high, 9–11.5 x 8.5–10.3 μ.

The existence of this species shows that *S. floccopus*, usually characterized as a very isolated form, is only one out of a whole series of closely related species.

SPECIES IMPERFECTLY KNOWN

Strobilomyces polypyramis Hook. fil. *apud* Berk., Dec. Fung., Hook. Journ. Bot. **3:** 78. 1851.

The type comes from India. I have not seen any specimens. This is probably another species of this section.

Strobilomyces montosus Berk., Dec. Fung., Hook. Journ. Bot. **3:** 78. 1851.

The type comes from India. I have not seen any specimens. This may be another species of the *Floccopus*-complex.

Strobilomyces echinatus Beeli, Bull. Soc. Roy. Bot. Belg. **58:** 212. *pl. 15, fig. 11.* 1926.

The type comes from the Belgian Congo. I have not seen any specimens, but this species appears to be remarkable because of the acuminate disc, and the punctate spores (according to Gilbert, Bull. Soc. Mycol. Fr. **52:** 258. 1936). It probably belongs in this section.

Sect. **Pterospori** Sing. sect. nov.

Sporis de apice usque ad hilum alato-costatis.

Characters of the section: see key (p. 106) and the above Latin diagnosis.

Strobilomyces pterosporus Sing. spec. nov.

PLATE I, FIG. 8.

Pileo umbrino-fuligineo, inter squamas subpallidiore, squamis umbrino-atris, appressis maculato, plus minusve 40 mm. lato, convexo; tubulis griseo-brunneolis in adultis, longissimis (radio pilei longioribus), circum stipitem depressis, poris concoloribus, irregularibus, compositis, angulatis, amplis, superficiem hymenophoralem ventricosam efformantibus; sporis fuscis vel melleo-fuscis sub microscopio, atris in cumulo, longitudinaliter (6)–12-costatis vel -alatis, ornamentatione 1.6–2 μ alta, ad polum apicalem abrupte levibus, 16.5–21 x 14–14.5 μ; basidiis tetrasporis, circa 25 x 17 μ; cystidiis

versiformibus; hyphis tramalibus haud fibuligeris; stipite concolori, centrali, plus duplico longiore quam diameter pilei, e velo ipsum apicem stipitis approximante fibroso-tomentoso, cylindrico, solido; carne pallida, mutabili, tenui (1–3 mm.) in pileo. Habitatio: Ad terram in silvulis intersecatis apricis Augusto mense. In Liberia Africae Tropicalis Occidentalis, Firestone # 3, Du River. *D. H. Linder 312* (FH).

Strobilomyces costatisporus (Beeli) Gilb., Bull. Soc. Mycol. Fr. **52:** 260. 1936.
Boletus costatisporus Beeli, Bull. Soc. Roy. Bot. Belg. **59:** 162. 1927.

Described from the Belgian Congo, this species differs from *S. pterosporus* in being larger, but having shorter tubes and smaller pores, and also definitely smaller spores. I have not seen any specimens. *S. lepidellus* Gilb. (Bull. Soc. Myc. Fr. **52:** 259. 1936) nom. subnud., has, as far as I know, not been validly described since, and therefore cannot be compared with either *S. pterosporus* or *S. costatisporus*.

Porphyrellus Gilb., Bolets, p. 99. 1931.
Phaeoporus Bat., Bolets, p. 11. 1908, *non* Schroeter, Krypt. Fl. Schles. (1888).
Boletus subgen. *Porphyrosporus* Smotlacha, Monog. Cesk. h. Hřibov. p. 31, 1911.[2]

Characters of the genus: see key (p. 106). Type species *Boletus porphyrosporus* Fr., i.e. *Porphyrellus pseudoscaber* (Secr.) Sing.

Sect. **Tristes** Sing. sect. nov.
Pileo haud laete colorato; sporis plerumque levibus; carne fortiter colorata reagentium alcalinorum ope.

Characters of the section: see key (p. 107), and the above Latin diagnosis. Type species *Boletus tristis* Pat. & Baker.

DESCRIPTION OF THE SPECIES OBSERVED IN FLORIDA

Porphyrellus pseudoscaber (Secr.) Sing. comb. nov. ssp. **typicus.**
Boletus pseudoscaber Secr., Mycogr. Suisse **3:** 13. 1833.
Boletus porphyrosporus Fr. in Hök, Boleti, p. 13. 1835.
Krombholzia porphyrospora Karst., Hattsw., p. 17. 1882.
Gyroporus porphyrosporus Quél., Enchir., p. 162. 1886.
Boletus nebulosus Peck, 51st Rep. N. Y. St. Mus., p. 292. 1898.
Boletus umbrosus Atk., Journ. Myc. **8:** 112. 1902. *sec.* Snell.
Phaeoporus porphyrosporus Bat., Bolets, p. 11. 1908.
Tubiporus porphyrosporus Ricken, Vademecum, p. 205. 1918.
Porphyrellus porphyrosporus Gilb., Bolets, p. 99. 1931.

There is no need for a detailed description of the type subspecies, since Kallenbach has given a fairly complete account on the European species, and Snell has described the American collections (see the following illustrations: Die Pilze Mitteleuropas, pl. 26, *fig.* 1–13, and Mycologia **24:** 336. 1932). I found the spores (average of several measurements on various materials from Austria) 13.5–19–(20.4) x 6.3–8.5–(10.2) μ, and among

[2] *Porphyrosporus* Smotlacha has been incorrectly cited as a genus by both Gilbert and Kallenbach.

them some smaller spores, several of which (among several hundreds of normal spores) have warts imbedded in the pallid exosporium, 8–9 x 5.4–6 μ; basidia 34–41 x 13.5–15.3 μ, 4-spored; cystidia fusoid-mucronate with the tip rather acute or quite acute, hyaline or more often brown, especially in old specimens; trama of the hymenophore and structure of the cuticle exactly as in ssp. *cyaneocinctus* Sing. (p. 117), the hyphae of the trichodermium are illustrated in Kallenbach, l.c., *pl. 33, fig. 47* [10,11,15]. Old herbarium material from Europe (*Hoehnel*, FH) did, however, not show a true trichodermium. This latter was preserved in but a few fragments, in others the repent thin cylindric hyphae of the surface (up to 6.5 μ in diameter) were either the remaining base of the trichodermium after it had been rubbed or washed off, or such a trichodermium is not constant in European plants. The context of the European form is also variable. Sometimes there is no bluing at all, and these forms are mostly found in coniferous woods (see Singer, Pilze aus dem Kaukasus, Beih. Botan. Centralbl., Abt. II, **48:** 519. 1931); they also were described as a variety, *Boletus porphyrosporus* var. *minor* Bat. & Crawshay (Bull. Soc. Myc. Fr. **39:** 267. 1924) but the decision whether these variations are indications of the presence of a collective species in Europe, or merely fluctuations within an homogeneous species, must be left for European mycologists. W. H. Snell's American collections have, notwithstanding statements to the contrary by the original authors of evidently identical species, all more or less bluing flesh, and seem to represent a single form, certainly identical with at least a part of the European *P. pseudoscaber* ssp. *typicus*. In the type of *Boletus nebulosus*, the larger spores are thin-walled, and the smaller ones thick-walled, fusoid or ellipsoid, or constricted; the dimensions of the spores are extremely variable as far as the length is concerned (variation of 100%), but little variable in breadth: 11–20.5 x 5.8–7.5 μ, mostly 12.5–15.5 x 6–7 μ; basidia large, 4-spored; cystidia brown often clavate, often gigantic; trama truly bilateral as in ssp. *cyaneocinctus*; epicutis of erect to repent clampless hyphae, some fascicles of hyphae forming fragmentary trichodermia, terminal members of the chains 5–11 μ in diameter, subfusoid, or clavate, not subulate. When trying to distinguish the typical form of Europe and of the northern part of the Atlantic Coast States from ssp. *cyaneocinctus*, one should keep in mind that most boletes tend to become rimose-tessellate in age, and unless several observations on many specimens corroborate the first observations, the positive finding should not necessarily mean that the form studied is ssp. *cyaneocinctus*. It is also important to note that the characteristic color ring of the latter subspecies does not serve to distinguish dried specimens, since it disappears on drying.

3. **Porphyrellus pseudoscaber** (Secr.) Sing. ssp. **cyaneocinctus** Sing. nom. nov.

Boletus fumosipes Peck, Ann. Rep. N. Y. St. Mus. **50:** 108. 1897, *pro parte*.
Ceriomyces fumosipes Murr., Mycologia **1:** 154. 1909.

Pileus "snuff brown" to "Saccardo's umber" with paler portions, velutinous or subvelutinous, cracking readily into areoles so that all adult speci-

mens are conspicuously rimose-tessellate, the crevasses whitish and running in all directions, not viscid, convex, 25–115 mm. broad. — *Hymenophore* between "cartridge buff" and "cream buff," becoming grayer, and eventually with a tinge from the spore color, greenish blue on injury, tubes up to 21 mm. long, deeply depressed around the stipe, leaving no sterile margin outward, pores forming a very convex outer-lower surface, concolorous with the tubes, and discoloring on injury the same way as these, the discolored patches finally becoming chestnut brown, diameter up to 2 mm. i.e. rather wide when mature; *spore print* "warm sepia" in a good print. — *Stipe* pale yellowish at the very apex with lamelloid proliferations of the walls of the tubes which run down to a characteristic though sometimes indistinct greenish blue to green ("deep lichen green" to "Rejane green") color ring below which the stipe is "wood brown," rarely without an apical coloring, extremely faintly fibrillose or velutinous on pale yellowish ground, later becoming "Saccardo's umber," subequal usually with thickened base, solid, 46–70 x 12–16 mm. — *Context* white, on exposure staining "porcelain blue" to "gobelin blue" near the tubes, but almost entirely bluing when young and fresh specimens are squeezed, the expressed sap coloring white paper blue, slightly dirty lilaceous under the cuticle, mostly more or less bluish in the apex of the stipe; odor none; taste somewhat sour.

Spores variable in shape, usually more or less fusoid, also ellipsoid-oblong, 10.5–14.3–(18) x (4.5)–6–(7.7) μ, with suprahilar depression, rarely without it, usually with a wall consisting of a brownish inner layer and a hyaline or pallid, thin exosporium which looks like an optical halo when well developed and seen under oil immersion, the exosporium usually optically empty, and then the spores definitely smooth, or in some rare cases perforated with thin cylindric spines which do not emerge above the surface of the exosporium but make the spore appear punctate when the upper surface is in focus, the walls occasionally seemingly thick but this is caused by the invisibility, in some instances, of the inner surface of the main wall so that the latter seems to extend from the surface of the spore to the surface of the oil drop, but occasionally actually thick, especially in the apical, rarely in the basal portion; *basidia* 4-spored, 30–36 x 9.5–14.5 μ; *cystidia* fusoid, or broadly ventricose-mucronate, but obtusate, hyaline to brownish, 35–58 x 10–20 μ; *trama* of the young tube walls truly bilateral, but very soon becoming xerocomoid, i.e. bilateral-subregular, the mediostratum initially darker and denser, soon all hyphae equally colored and equally dense, lateral stratum initially divergent, soon divergent but in a narrow zone where the trama turns into the subhymenium; *cuticle* a trichodermium, consisting of a hymeniform epicutis with dermatocystidioid terminal members of erect hyphae, arising from a subcuticular layer of more or less erect hyphae which frequently are to a certain extent broken down into chains of almost cubical to globose elements, and have a larger diameter than the basal septum of the cystidioid elements of the epicutis, the latter (dermatocystidia) subulate, a smaller number of them fusoid, the very apex rounded, 26–42 x 7–14 μ, hyaline, smooth.

Chemical reactions. **KOH** on surface of pileus purplish to reddish but not as bright as with NH_4OH; on context "Etruscan red," becoming "vinaceous tawny." — **NH_4OH** on the surface of the pileus deep purple ("dark livid brown"), the center of the reacting spot eventually "English red"; on context at some places reddening then browning, at others sordid (little reaction). — **HNO_3** on context brownish. — **$FeSO_4$** "deep glaucous gray" or "dark glaucous gray." — **Formol** salmon color. — **Methylparamidophenol** negative.

Habitat: Under oaks on the soil, gregarious. May to August. Rather frequent though not abundant anywhere.

Distribution: New York to North Florida, and "west to Kentucky" according to Murrill. In Florida known only from Gainesville, but certainly of quite general occurrence in North Florida.

Material studied: **Fla.,** Alachua Co. Gainesville, under Evergreen oak (*Quercus laurifolia*), Aug. 1937, *W. A. Murrill* (*Boletus fumosipes*) (FLAS, **co-type**); also other collections in high hammocks under oaks, June 1–July 25, 1943, *Singer F 2193, 2607, 2825* (FH, **co-types**). — **N. Y.: Type,** also **type** of *Boletus fumosipes*, p.p. (NYS).

As pointed out by Snell, a portion of the type of *B. fumosipes* Peck has striate spores and belongs to *Boletellus chrysenteroides* Snell, while another portion has smooth spores and this seems to be the basis of Peck's description. However, the fact remains that the type of *B. fumosipes* is a mixed sample, and no type specimen is designated. The author therefore preferred to avoid Peck's name by choosing a new name for the subspecies described above which has been called *Boletus fumosipes* by Murrill, and *B. sordidus* by Coker and Beers.

EXTRALIMITAL SPECIES

Porphyrellus tristis (Pat. & Baker) Sing. comb. nov.

Boletus tristis Pat. & Baker, Journ. Straits Branch R. Asiatic Soc. No. 78: 70. 1918.

I have studied the type in the Patouillard Herbarium (FH). This is an interesting species. The stipe is subvelutinous, somewhat thickened at the base, the tubes are subadnate at maturity, wide in age, 3.5 mm. long when fresh. The spores are fusoid to boat-shaped, porphyry-umbrinous, darker than all other elongate spores known in this family and in the Boletaceae, reminding one of *Psathyrella* (*Psathyra*), transparent, smooth, some attenuate almost from the base up, wall thin though not extremely so, the outer layer in some cases slightly obscurely cloudy-punctulate with paler and darker brown zones, 14–17–(19) x (3)–4–5.5 μ, with or without a suprahilar depression; basidia 4-spored, 9.5–12.5 μ broad. The cystidia are fusoid with rounded tips, or subulate, variable in size, hyaline, crowded at the pores. The trama of the tube walls is truly bilateral with a melleous to mahogany brown rather narrow mediostratum, and a hyaline, strongly divergent, somewhat looser, lateral stratum. The cuticle of the pileus is characterized by erect dermatocystidioid terminal hyphae which form an

epicuticular trichodermium-palisade; they are brown, fusoid-ventricose and rounded above, or fusoid-mucronate, 70–100 x 14–28 μ. The velvet of the stipe is formed by thin brown erect hyphae with a capitate-balloon-shaped or clavate terminal hypha, 15–28 x 9–10 μ (very characteristic). All hyphae have clampless septa.

The flesh of this species is said to be white and unchanging, but the same statement has been made on other species of this group. The color and the whole appearance strongly suggest *P. pseudoscaber* which is the nearest species we know. The strange heterogeneity of the exosporium of many spores is indicative for the origin of the ornamentation of the spores in the Strobilomycetaceae by alternating condensations in the exosporium.

This species has been abundantly collected in Singapore but not elsewhere.

SPECIES IMPERFECTLY KNOWN

Boletus sordidus Frost, Bull. Buff. Soc. Nat. Sci. **2:** 105. 1874.

Ceriomyces sordidus Murr. N. Am. Fl. **9** (3): 149. 1910.

Boletus sordidus reminds one of both the type subspecies and the more southern subspecies *cyaneocinctus* Sing. of *Porphyrellus pseudoscaber*. The spores are 10–15–(17.5) x (4)–5.5–7.5–(9.7) μ much the same as in *P. pseudoscaber* if the measurements are expressed in range limits as above, but actually differing in being enormously variable as well in length as in breadth, some spores being as short as 10–11.5 x 6–7 μ, approaching the shape of the most elongate spores of *Strobilomyces velutipes*. The walls of the broadest spores of *B. sordidus* are very thick and have more or less incomplete germ pores at the apex which may also be applanate as in *Ganoderma*, the walls reaching 1.7 μ in diameter at the apical end.

The above data have been taken from authentic material received at Farlow Herbarium from the Boston Society of Natural History where some of the types of Frost's were preserved; it is very probable that this specimen actually represents a portion of the type collection. The type has been described from Vermont, but fresh material has thus far been re-collected neither there nor elsewhere in New England, and it is to be feared that *B. sordidus* is merely a form with abnormal spores of one of the two established subspecies of *Porphyrellus pseudoscaber*, either as Snell first thought (l.c.) ssp. *typicus*, or as he later says (Mycologia **28:** 475. 1936) *Boletus fumosipes* Peck, i.e. *Porphyrellus pseudoscaber* ssp. *cyaneocinctus* Sing. As it seems to me, *Boletus sordidus* has to remain among the dubious species of *Porphyrellus*, sect. *Tristes* until further evidence shows its correct position.

Sect. **Graciles** Sing. sect. nov.

Pileo laete colorato; sporis perforato-punctatis; stipite subreticulato vel lacunoso-favoso; actione acidorum et alkalium haud intensa.

Characters of the section: see key (p. 107) and the above Latin diagnosis.

KEY TO THE SPECIES

A. Stipe merely finely and sometimes obscurely, reticulate, not lacunose. *P. gracilis.*

A. Stipe deeply anastomosing costate, and lacunose because of these anastomoses, the ribs lamellose in shape and waxy in consistency.

B. Spores 14.5–18 x 6.5–8.2 μ. Pileus 47–107 mm. in diameter.
4. *P. subflavidus*

B. Spores 10–14 x 5–6.8 μ. Pileus 40 mm. broad. *P. malaccensis*

4. **Porphyrellus subflavidus** (Murr.) Sing. comb. nov.

Tylopilus subflavidus Murr., Mycologia **30** (5): 520. 1938.
Boletellus subflavidus Snell, Mycologia **33** (4): 422. 1941.

PLATE I, FIG. 4.

Pileus yellowish to almost argillaceous, or whitish, or with pallid center, most frequently about "Massicot yellow" and eventually often "clay color" when the weather is dry, occasionally with a slight "pale ochraceous buff" or "pale ochraceous salmon" tinge, flocculose-velutinous, usually becoming rimose-areolate, eventually frequently fibrose-squamose, not viscid, convex, at length slightly depressed, 47–107 mm. broad. — *Hymenophore* pallid grayish with a vinaceous tint, eventually almost as in *Tylopilus conicus*, very convex or forming a wall near the depression which surrounds the stipe, tubes long (11–21 mm.), pores concolorous, rather wide; spore print on white paper "warm sepia," in thinner layer "Army brown" or "Verona brown." — *Stipe* yellowish white, pale yellow, or light yellow, lamellose to alveolate-lacunose, solid, occasionally becoming hollow in age, cylindric, or tapering down, the base usually acuminate, more rarely bulbose, 45–145 x 7–30 mm. — *Context* pure white, in the base of the stipe usually rich yellow, unchanging in all parts; odor slight, fruity, or almost none; taste bitterish.

Spores melleous with brown markings, somewhat less rich-colored than in *Boletellus betula*, with subsmooth to crenulate outline, the exosporium with imbedded, thin, cylindric spines which when seen from above make the spore appear punctate, fusoid, with a slight suprahilar depression, 14.5–18–(20.5) x (6)–6.5–8.3–(8.8) μ; *basidia* 4-spored, 33–38 x 11.5–15.5 μ; *cystidia* not as striking as in most species of this family, versiform, i.e. clavate-fusoid, irregularly fusoid, elongate-claviform, fusoid-ampullaceous, etc., moderately numerous, 27–54 x 5.5–10.2 μ, hyaline, not incrusted; *trama* of the tube walls truly bilateral, the mediostratum thin, very pale melleous, denser than the strongly diverging, loose, pure hyaline lateral stratum, hyphae without clamp connections, somewhat wavy in the mediostratum, and somewhat gelatinizing in the lateral stratum, multi-septate, especially in the mediostratum and, as usual, in the subhymenium; *cuticle* of the pileus consisting of a trichodermium, the erect hyphae of the outermost layer with ascendant or irregular basal hyphae, more or less fasciculate, loose, and not parallel, with cylindric, cylindric-subcapitate, or clavate terminal hyphae which are neither colored nor incrusted, and have a not extremely thin wall, broadly rounded above, 30–78 x 3.5–11.5 μ; lamellae of the stipe formed by rather parallel, thin, tender, thin-walled, cylindric,

multi-septate, clampless hyphae of 3–3.5 μ diameter, the surface formed by somewhat inflated, hyaline dermatocystidia e.g. 38 x 11.3–11.5 μ.

Chemical reactions: **KOH** on pileus cinnamon buff; on context negative; **NH_3** on pileus avellaneous; **NH_4OH** on pileus cinnamon buff; on context negative; **HNO_3** on pileus yellow; on context negative; **$FeSO_4$** on context negative.

Habitat: In high hammock vegetation, under *Quercus virginiana* and *Q. laurifolia*, and in flatwoods under *Pinus palustris* with *Quercus minima*, on the sandy soil, usually gregarious. June to October.

Distribution: Northern Florida.

Material studied: Alachua Co., *Murrill* (FLAS, **type**); authentic material (FH); *Singer F 2200, F 2539, F 2673, F 2842* (FH).

A well-defined species among the Strobilomycetaceae of this country, but closely allied to *P. malaccensis* and *P. lacunosus*.

EXTRALIMITAL SPECIES

Porphyrellus gracilis (Peck) Sing. comb. nov.

Boletus gracilis Peck, Ann. Rep. N. Y. St. Mus. **24:** 78. 1872.
Tylopilus gracilis Henn. in Engl. & Pr., Nat. Pfl. **1** 1**: 190. 1897.

PLATE I, FIG. 5.

I have studied authentic material sent to Patouillard by Peck (from Ballston, N. Y.). This material seems to be identical with the Albany types (NYS). It is remarkable that no author has as yet seen the characteristic structure of the spore wall which is perforated, as in *Ganoderma*, by brown cylinders, scarcely projecting above the surface of the exosporium, but making the spore clearly appear punctate when the upper surface is focussed upon; they are 11–15.3–(17.5) μ long and (5.5)–6.5–6.7 μ broad, melleous, basidia four-spored, 24–30 x 9.8–11.8 μ. The cystidia are versiform, similar to these of the preceding species. Macroscopically, this species resembles a new species of *Tylopilus*, related to *T. felleus* which will be described in the second part of this paper. Old spore preparations are of the same color as in *P. pseudoscaber*, not as in *Tylopilus*. Coker and Beers indicate the spores as being "hazel" but a four-year-old good spore print from a specimen of Coker's was found to be "Sudan brown" by the writer. *P. gracilis* occurs in New York, New England, and North Carolina, and is said to be distributed "from Nova Scotia to Georgia." It has, as *Tylopilus gracilis* (Peck) Henn., been indicated by Murrill (Florida Boletes, Mim. Contrib. Herb. Univ. Fla. Agr. Exp. Sta., p. 2, 1942) as occurring in northern Florida. However, I was unable to find any evidence in the Herbaria consulted.

Porphyrellus malaccensis (Pat. & Baker) Sing. comb. nov.

Phylloporus malaccensis Pat. & Baker, Journ. Straits Branch R. Asiatic Soc. No. 78: 71. 1918.

It is hard to understand why this species has been published as a *Phylloporus*. It has nothing in common with that genus, and belongs in the

closest neighborhood of *P. subflavidus*. The type from Singapore, which is deposited in the Patouillard Herbarium (FH), is somewhat smaller than the Florida species, and has smaller spores, 10–14–(17.5) x 5–6.8 μ. No other difference between these two species can be discovered. Nevertheless we consider them as independent species.

SPECIES IMPERFECTLY KNOWN

Porphyrellus Cookei (Sacc. and Syd.) Sing. comb. nov.
Boletus lacunosus Cooke & Mass., Grevillea **18:** 5. 1889.

The type, which I have not seen, comes from Australia. This species evidently belongs in the *P. malaccensis-subflavidus*-group. If the spores are described correctly, this species would be distinguished easily by the spore measurements which are given as "15 x 10 μ" (Cooke & Massee). If it were not for this one character, I would be unable to point out how it could be distinguished from *P. subflavidus* unless "pileo subviscoso" indicates an actual difference in the structure and consistency of the cuticle.

SPECIES EXCLUDENDAE

Porphyrellus alboater (Schw.) Gilbert, Bolets, p. 99. 1931. This is a *Tylopilus* (Boletaceae).

Porphyrellus nigrellus (Peck) Gilbert, Bolets, p. 99. 1931. This is the same as *Tylopilus alboater* (Schw.) Murr.

Porphyrellus indecisus (Peck) Gilbert, Bolets, p. 99. 1931. This is a *Tylopilus* (Boletaceae).

Boletellus Murr., Mycologia **1:** 10. 1909, em. Gilbert, Bolets, p. 106. 1931.
Boletogaster Lohwag, Beih. Botan. Centralbl. **42** (2): 274. 1931.
Frostiella Murr., Mim. Contrib. Herb. Univ. Fla. Agr. Exp. Sta. Jan. 5, p. 6. 1942; Snell, Mycologia **34:** 409. 1942 (nomen nudum).

Characters of the genus: see key (p. 107). Type species *Boletellus ananas* (Curt.) Murr. (*Boletus ananas* Curt.).

Section **Ananae** Sing. sect. nov.

Pileo roseolo, purpurascente, rubello, rubido-vaccineo, saepe fortiter squamoso vel squamuloso-furfuraceo, haud viscido, margine velo appendiculato vel subnudo; sporis elongatis, longitudinaliter striatis vel vittatis, magnis (i.e. magnitudine majoritatis sporarum maturarum 17 μ excedente).

KEY TO THE SPECIES

A. The longitudinal ridges of the spores high (projecting about 1 μ above the surface of the spore); stipe sometimes red, but not red-tomentose above, nor squamulose, nor furfuraceous; pileus imbricate-squarrose, bearing large scales (see B1, B2, B3).

B1. Stipe umber brown; carpophore small. *B. porphyrius*

B2. Stipe pallid or white, sometimes becoming red at the apex or gray at the base, but never prevalently umber brown; carpophore medium to large. 5. *B. ananas*

B3. Stipe yellow above, red below; carpophore medium to large. *B. emodensis*

A. The longitudinal ridges of the spores usually low (projecting much less than 1 μ, or occasionally just reaching 1 μ height), never transversely veined-striate; stipe either red furfuraceous to tomentose above, or squamulose or furfuraceous; pileus minutely squamulose to glabrous, or tomentose-scrobiculate.

C. Stipe longitudinally striped red, white tomentose at the base, red tomentose-furfuraceous above, 100 x 12–13 mm.; pileus uneven, scrobiculate and tomentose, not scaly, not glabrous, 60–70 mm. broad. *B. obscurecoccineus*

C. Stipe not striped with red, not red tomentose-furfuraceous above, but distinctly furfuraceous or transversely squamulose, 30–50 x 4–9 mm.; pileus minutely squamulose or glabrous, 20–40 mm. broad. *B. cubensis*
B. lignatilis
B. guadelupensis

DESCRIPTION OF THE SPECIES OBSERVED IN FLORIDA

5. **Boletellus ananas** (Curt.) Murr., Mycologia **1:** 10. 1909.

Boletus ananas Curt., Amer. Journ. Sci. II **6:** 251. 1848; Berk., Hook. Journ. Botan. **1:** 101. 1849.
Strobilomyces pallescens Cooke & Mass., Grevillea **18:** 5. 1889.
Boletus isabellinus Peck, Bull. Torr. Club **24:** 146. 1897.
Boletellus pallescens Gilbert, Bolets, p. 107. 1931.
?*Boletus coccineus* Fr., Epicr., p. 423. 1838.
?*Strobilomyces coccineus* Sacc., Syll. **6:** 50. 1888.
?*Boletus ananaeceps* Berk., Linn. Soc. Lond. Journ. (Bot.) **13:** 161. 1873.
?*Strobilomyces ananaeceps* Sacc., Syll. **6:** 50. 1888.
?*Secotium excavatum* Kalchbr., Ertek Természz. Köreb Kiadja a Magy. Tud. Ak. **13** (8): 7. *pl. 3.* 1884.
?*Strobilomyces excavatus* Henn., Hedwigia **43:** 187. 1904.

PLATE I, FIG. 7.

Pileus with "deep vinaceous," or "Pompeian red" and "Isabella color" fibers, a general color of about "russet vinaceous" resulting, bleaching when old, fascicles of the fibres forming large woolly-squarrose or subimbricate scales which are the more erect the nearer they are to the center, non-viscid, subglobose at first, becoming convex-expanded, 45–95 mm. in diameter; margin extended into a thick membranaceous veil which is white or nearly so, and initially runs down the apex of the stipe in two indistinct layers, the outer one thin and fragmentary, later breaking off the stipe to leave a sleeve just above the surface of the stipe, finally becoming ragged to form a sordid and pale stramineous, irregularly crenulate-denticulate appendiculation on the margin; these remainders of the appendiculate veil disappear at or after maturity. — *Hymenophore* yellow, often tinged with reddish brown, staining blue where injured, eventually becoming yellowish brown or reddish brown all over; tubes depressed around the stipe, 11–16 mm. long; pores concolorous, large, irregular, angular, forming a distinctly convex lower surface; spore print black or nearly so. — *Stipe* white, or pallid, often with a red belt on the apex ("Pompeian red" or lighter, corresponding to the blue or green belt of *Porphyrellus pseudoscaber* ssp. *cyaneocinctus*), described as grayish below (Cleland for Australian specimens), but only becoming pinkish sordid or sordid when old in American specimens, subfibrillose-subglabrous to fibrous, but rarely with an actual annular remnant

of the veil on the stipe, not scaly-floccose nor shaggy, smooth, tapering upwards when young, later rarely with subbulbous base, or sometimes tapering downwards, or more frequently subequal, solid, 60–140 x 8–15 mm. — *Context* yellowish white or whitish yellow in the pileus, white in the stipe or only in the base of the stipe, readily and strongly bluing when cut, at least in the pileus, occasionally reddening in the stipe; odor none; taste mild.

Spores 13.8–25.5 x 7–11 μ, mostly 17.5–22.5 x 7.5–9.2 μ in American specimens, with strongly projecting longitudinal, slightly spiralling, lamellosely-thin wing-like ridges which abruptly are cut off before they reach the indistinct germinative pore, leaving a very narrow hole at the very apex of the spore, the sides of the ridges and the bottom of the furrows between them transversely venose-striate, the ridges numbering from 12 to 14, and measuring from 0.6–1.2 μ, mostly 1 μ in height; *basidia* 22.5–50 x 9.5–17.5 μ, 2- to 4-spored; *cystidia* fusoid, mucronate, or ampullaceous to ampullaceous-capitate, hyaline, brittle, 24–50 x 5–15 μ; *trama* of the tube-walls truly bilateral with more colored mediostratum and looser, divergent lateral stratum, the hyphae without clamp connections; hyphae of the outer layer of the *veil* hyaline, semiopaque, long-cylindric, irregularly interwoven, thin-walled, 4–7 μ thick, the septa without clamp connections, the terminal members of the hyphae long, with attenuate though rounded, or suddenly broadly rounded, or subcapitate tips.

Chemical reactions: **KOH** on context yellow, becoming brown; on the surface of the pileus olive-yellow, becoming maroon; **NH_4OH** on the surface of the pileus olive-yellow; **$FeSO_4$** on the context green; **aniline** negative; **chlorovanilline** on context becoming yellow where the context had been white (probably only the acid — HCl — reacting).

Habitat: In various kinds of woods, from open pine-oak woods to dense tropical hammocks, frequently on the bases of trees (*Pinus palustris, P. caribaea, Quercus virginiana, Q. Catesbaea, Nectandra coriacea*), or on shaded stone walls, climbing at times as high as three feet above the ground, but also on sandy soil under oaks or pines, solitary to gregarious. From May to November in the Northern Hemisphere, December to May in South Australia (according to Cleland).

Distribution: Southern States of the U. S. A., from South Carolina to the south tip of Florida and west to Alabama and Mississippi, probably reaching Mexico and the South Pacific Islands but known with certainty only from New Caledonia, also in Queensland and South Australia. In Florida through all zones.

Material studied: **Fla.:** Dade Co. Matheson Hammock and Fairchild Tropical Garden, September to November 1942, *Singer F 709, F 709a, F 709b, F 1391* (FH); Lake Co., Eustis, Oct. 1897, *Thaxter 2444*; Alachua Co., Gainesville, August 1937, *Murrill* (FLAS, FH); Sugarfoot Hammock, July 1943, *Singer F 2541, F 2541a* (FH); Newnan's Lake, July 1943, *Murrill* (FLAS); Madison Co., Cherry Lake, July, *Murrill* (FLAS): Marion Co., Goldhead Park, May, *Murrill* (FLAS). — **S. C.:** Santee River, **type** of *Boletus ananas* Curt. (Curtis Herbarium, FH). — **Ga.:** North-east Georgia, vicinity of the Tallulah Falls (Tallulah Falls, Bad Branch, Sunset Rock, Rock Moun-

tain), from August to September, *A. B. Seymour & W. L. Moss*, det. W. G. Farlow (FH).—**Ala.:** *Earle* (FH).—**Miss.:** **Type** of *Boletus isabellinus* (NYS).—**New Caledonia** (Nouvelle Calédonie): on iron-rich soil, *Le Rat, 1808*, det. Patouillard (*S. pallescens*), (FH).—**Queensland,** Australia: **Type** of *Strobilomyces pallescens* (NY).

Coker and Beers, and also Murrill, Earle, and others emphasized the growth of the carpophores on the base of trees, exclusively pines as it was understood by these authors. Earle supposed parasitism, and Murrill based the genus *Boletellus*, among other characters, on the epixylous growth of the carpophores. This, however, is not in full agreement with the facts. I have in numerous careful observations never been able to find any injury on trees that could be attributed to this fungus, nor is it true that this species is always epixylous, or confined to pines. At some stations, there were absolutely no pines in the vicinity, and at others, the carpophores definitely preferred the bases of oak trees to those of pines in a mixed stand. The fact that many specimens grew, of all places, on scanty humus and débris on stone walls, the mycelium appressed to the rocks, seems to show that *Boletellus ananas* merely prefers to grow along hard surfaces, but most certainly it is not a parasite unless, of course, the mycelium is connected with the roots, and has loose mycorrhizal relationship with oaks and pines, with possible disturbances of the mutual character of the symbiotic relations in favor of the fungus, as it happens under certain conditions with other boletes. However, the lack of specialization on the part of *B. ananas*, as well as the growth on stone walls instead of close to the roots of the trees, or on the ground under trees, makes it highly dubious whether it is a mycorrhizal fungus at all. Without experimental studies proving the fact of actual formation of mycorrhiza, field observations are not sufficient to answer this particular question. At any event, the idea that *B. ananas* is an exclusive parasite of pine trunks must now be abandoned. Another interesting fact about *B. ananas* is the geographic area occupied by this species. If it is interrupted, this would by itself constitute a rare and interesting phenomenon, but it may well be that the many little explored regions and small islands between the known areas, after more exploration, will furnish a bridge between the American and the Australo-Oceanic centers of distribution.

The spores seem to average a trifle larger in the Australian plant, but we obtained two practically identical measurements from the New Caledonian material in Patouillard's Herbarium and from our Dade Co. (Fla., U. S. A.) collections: 19–22.5 x 8–9.5–(11) μ in New Caledonia, and 18–22.5 x 8.8–9.2 μ in South Florida. There is also Cleland's indication that the stipe is gray below, but Cooke (Queensland-type) says it is pallid. It seems therefore that these spurious differences cannot be used for the substantiation of geographic races. Lloyd's *Strobilomyces pallescens* from this country is, no doubt, plain *B. ananas*.

Krieger (The Mushroom Handbook, p. 441. 1936) uses the name *Strobilomyces coccineus* (Fr.) Sacc. for our *Boletellus ananas*. As for the ge-

neric name, I refer to the observations in the present paper (p. 105); the specific name has the advantage of being undoubtedly the oldest possible name having priority over *Boletus ananas*. When Fries described this species, he based his data on Plumier's laconic characterization and somewhat fantastic picture in black and white. Notwithstanding the very inadequate description and the poor drawing, it is hard to imagine what other species it could possibly represent. On the other hand, it has to be remembered that Plumier gives no locality, and all we know is that it was found somewhere in America. Nobody has ever heard of there being any specimens preserved. This is, in my opinion, not enough evidence to unsettle an established name like *B. ananas*, and Murrill is right in referring to *Boletus coccineus* in the list of doubtful species. Murrill also was right in referring *Boletus isabellinus* Peck to *Boletellus ananas* as a synonym. The type specimens at Albany do not leave any doubt as to their identity. If there is the slightest similarity between plate 3 of Kalchbrenner (l.c.) and the fungus painted, this latter, *Secotium excavatum*, cannot be a *Boletellus*, and by no means *B. ananas*. But Hennings who has seen the "originals" flatly declares *Boletus pallescens* and *Secotium excavatum* to be synonyms. Reexamination of the types of the latter will decide if he is right.

EXTRALIMITAL SPECIES

Boletellus porphyrius (Pat. & Baker) Gilbert, Bolets, p. 107. 1931.
Strobilomyces porphyrius Pat. & Baker, Journ. Straits Branch R. Asiatic Soc. No. 78: 72. 1918.

Described from Singapore, this species has been transferred to *Boletellus* by Gilbert because of the indication in the original description "Spores longitudinally striate" and because of the sordid yellowish hymenium. The examination of the type reveals that *Boletellus porphyrius* actually belongs in this genus, and that it can be characterized as a smaller *B. ananas* with umber brown stipe. The spores are the same in both these species. I found them with exactly the same double markings as in *B. ananas* and of the same size: 17.5–21 x 7.5–9.5 μ. Basidia 32–46 x 12–18 μ; hyphae without clamp connections.

Boletellus emodensis (Berk.) Sing., Ann. Mycol. **40:** 18. 1942.
Boletus emodensis Berk., Hook. Journ. Bot. **3:** 48. 1851.
Strobilomyces annamiticus Pat., Bull. Soc. Mycol. Fr. **25:** 6, *pl. 1, fig. 1*. 1909.
Boletellus annamiticus Gilbert, Bolets, p. 107. 1931.

The characters of this beautiful Asiatic species are plainly those of the section *Ananae*, even the peculiar veil of *B. ananas* being well represented. The originals of Hooker's paintings of Sikkim fungi are preserved at Farlow Herbarium, and they show clearly enough that *B. emodensis* is very similar to *B. ananas*. We have not studied the types which are in England, but we have had material from China, province of Kwangsi, and the types of *Strobilomyces annamiticus* Pat. in the Patouillard Herbarium. The latter is doubtless a mere form of *B. emodensis* if not a plain synonym. The

spores of *B. emodensis* are 18–22.5 x 8.3–11 μ with the wings transversely striate, and 1–1.5 μ high. The spores as indicated by Patouillard come from immature material. Immature carpophores of the Chinese collection have the same spores as indicated by Patouillard (though there is a printing error in his description: 10 instead of 20 μ). The basidia are 39–68 x 12–14.3 μ. The cystidia we have seen are smaller than the basidia or equal the basidia and they are smaller than indicated by Patouillard. The lateral stratum of the hymenophoral trama is distinctly divergent. The mycelium of all specimens is very strongly developed, forming a large, sometimes yellow tomentum. This species differs from *B. ananas* in the color of the stipe, and possibly the deeper red of the pileus and of the hymenophore. It also differs from *B. porphyrius* in the colors and the size. Nevertheless, these three species form a closely related group (a stirps) within the section. This stirps is characterized by the marginal veil, large spores with double ornamentation, and scaly pileus. *Boletus squamatus* Berk. is probably another species of this group, if it is not a synonym of *B. emodensis* with somewhat faded colors.

Boletellus obscure-coccineus (Höhn.) Sing. comb. nov.
Boletus obscure-coccineus Höhnel, Sitz.-ber. Akad. Wiss. Wien **123** (1): 88. 1914.

Höhnel, who collected and described this species in Java, mistakenly thought it was especially close to *Boletus versicolor* i.e. *B. rubellus* Krombh. The type specimens preserved in the Herbarium Höhnel (FH) show that it is a *Boletellus* with the hymenophore convex beneath, 8–9 mm. thick, and the spores 15.5–21 x 7.5–8 μ, melleous when mature (not brown) with comparatively thin walls but with distinct, fine, venose, longitudinal ridges. Basidia 30–42 x 8.5–12.5 μ, 4-spored. Cystidia mucronate, about 100 μ long and 14–24 μ broad. Hyphae of the tube-trama hyaline, cylindrical, smooth, without clamp connections. This species reminds one macroscopically of *Boletellus emodensis*, and microscopically of *Boletellus cubensis* and its allies.

Boletellus cubensis (B. & C.) Sing. comb. nov.
Boletus cubensis Berk. & Curt., Journ. Linn. Soc. **10:** 304. 1868.

The spores of the fragment of the Kew type (NY) are 20–22.5 x 7.5–10 μ, and striped with longitudinal low ridges (less than 1 μ high), deep melleous, fusoid, somewhat truncate at the apex, the ridges slightly anastomosing but not transversely veined as in *Boletellus ananas*, with suprahilar depression. This shows that it belongs in the neighborhood of *Boletellus obscure-coccineus*. It may well be that it will be discovered in South Florida or on the Keys since many Cuban species have been found there by the writer.

Boletus lignatilis Berk. & Curt., Journ. Linn. Soc. **10:** 303. 1868.

This species also comes from Cuba, and the spores of the fragment of the Kew type (NY) are longitudinally ridged (ridges up to 0.8 μ high) and the ridges connected by occasional to frequent anastomoses (but not

transversely venose as in *Boletellus ananas* or *B. chrysenteroides*). They are deep melleous and depressed above the hilar end, 18–21.5 x 7.5–9 μ. This is doubtlessly a *Boletellus* of this section, but no new combination is proposed because of the probability that this and the preceding species are identical.

Boletus guadelupensis Pat., Bull. Soc. Myc. Fr. **16:** 177. 1900.

Collected on Guadeloupe, West Indies, this is possibly another synonym (a younger stage) of *Boletellus cubensis* (B. & C.) Sing. The spores of the type (FH) are 14–19.5 x 6.5–8.5 μ, and longitudinally striate from the hilar end to the tip where the striae suddenly end, very few mature (colored) spores remaining smooth or almost so, melleous, the walls browner, with a slight suprahilar depression or applanation; I have not seen the yellow prominent cystidia. According to the original description, this species differs from *B. cubensis* in chestnut brown pileus and appendiculate margin. The former difference may be due to the fact that the specimen dried to that color, but was reddish when quite fresh, as is evident in the dried specimen. This may be explained by the hypothesis that this species represents a younger stage of *B. cubensis* which would also account for the smaller size of the whole carpophore as well as of the spores. There are also minor differences in the description of the surface of the stipe. Nevertheless, I think it is necessary to refrain from transferring *B. guadelupensis* to *Boletellus* as an independent species, as long as no data on the fresh plants are available. Unfortunately the Cuban plants as well as *B. guadelupensis* seem to be rare.

SPECIES IMPERFECTLY KNOWN

Boletus squamatus Berk., Hook. Journ. Bot. **4:** 137. 1852.

I think that this Indian species is another member of the section *Ananae*, but since nothing is known about the spores, further studies are necessary, before a new combination can be justified. Berkeley thinks that his species is allied to *Boletus subtomentosus* and *B. chrysenteron*, but Hooker's original painting reminds one of *Boletellus porphyrius* and *B. emodensis* rather than of any *Xerocomus*.

Sect. **Mirabiles** Sing. sect. nov.

Pileo minute tomentoso vel squarroso, margine secedente sterili; stipite plus minusve reticulato; sporis giganteis, levibus.

Characters of the section: see key (p. 107), and Latin diagnosis above. This is a remarkable section because of the enormously large, smooth spores, and the projecting margin. It has been treated by Singer conditionally in *Xerocomus*, but it actually is close to the remaining sections of *Boletellus*. The type species is *Ceriomyces mirabilis* Murr. There are no representatives of this section known to occur in Florida.

Boletellus mirabilis (Murr.) Sing. comb. nov.
Ceriomyces mirabilis Murr., Mycologia **4:** 98. 1912.
Xerocomus mirabilis Sing., Rev. Myc. **5:** 6. 1940.

The type of this western species has been studied by the writer and compared with material obtained by Alexander H. Smith. As I said in 1942, "The exact structure of the trama could not be stated. If this would be extremely bilateral, generic separation from *Xerocomus* should be taken in consideration." Actually, the trama of the tube walls *is* truly bilateral. The spores are 18–26.3 x 7–10.5 μ, smooth, ellipsoid-oblong to subfusiform or fusiform, yellowish brown (color in mass unknown to me), wall 1–1.8 μ thick, but also thinner in many cases, slightly obtusate at the apex in many cases, with suprahilar applanation; basidia 33.5–39 x 10–14.5 μ, 4-spored; cystidia 60–80 x 11–16 μ, ventricose or ampullaceous or more or less strongly capitate above, or plainly fusoid; hyphae of the truly bilateral trama without clamp connections and divergent in the lateral stratum; papillae of the cuticle consisting of chains of thin (about 8 μ), or thick (10–18 μ) clampless hyphae, in the latter case attenuated toward the septa, brown, about 20–60 μ long between septa, the terminal member occasionally shortened, and rarely spherocystoid. Kauffman (Pap. Mich. Acad. Sci. Arts & Lett. **5** (1925): 115. 1926) redescribed this species from Mt. Hood, Ore. (*Wehmeyer 28130*, MICH). Snell had it from Manitoba, Slip and Snell indicate it from Idaho, the type came from Washington, and Overholts indicates it in Pennsylvania. This latter extension of the area of distribution is surprising, if true.

Boletellus projectellus (Murr.) Sing. comb. nov.
Ceriomyces projectellus Murr., Mycologia **30:** 524. 1938.
Boletus projectellus Murr., Mycologia **30:** 525. 1938; Coker & Beers, Boletaceae, p. 51. 1943.

This species has been found in Virginia and North Carolina, U. S. A. For a good macroscopical description and a colored picture see Coker and Beers, *l.c., pl. 1, fig. 3–4.* The type specimens (*Murrill F 9296*, FLAS), authentic material (*J. N. Couch F 16045*, FLAS) and other North Carolina material (*J. N. Couch 13193*, FH), were compared by the writer and found to be identical. Couch's collections are evidently the basis of the description and plate of Coker and Beers. The anatomical characters of these plants have been found to be as follows: spores (20)–22–30–(32) x (5.8)–8.5–11–(12) μ, smooth, melleous to deep melleous, the walls 1–1.5 μ thick when mature, the upper portion attenuated from the lower third, or the outline more evenly elliptic-oblong to boat-shaped in frontal view, with a slight depression in profile, always more or less acuminate though obtuse at both ends, the inner wall interrupted and the germ pore incomplete since the exosporium is continuous; basidia 23–36 x (10)–12–15 μ, 4-spored, few 2-spored; cystidia fusoid with ampullaceous apex, or lanceolate with obtuse tip, hyaline, (33)–35–70 x 10–17 μ; trama truly bilateral, the mediostratum slightly denser and dilutely colored, the lateral stratum somewhat diverg-

ing (in nearly adult specimens), clamp connections none. *Boletellus projectellus* is one of the representatives of the Agaricales with the longest spores, and belongs to the species with the most voluminous spores of the whole order. It certainly has the largest spores of all boletes.

Sect. **Retispori** Sing. sect. nov.
Sporis breviusculis, reticulatis.

Characters of the section: see key (p. 107) and the Latin diagnosis above. The section is unique in combining spores of the type of *Strobilomyces floccopus* with entirely different macroscopical features. The only species is *Boletellus retisporus* which has not been found in Florida.

Boletellus retisporus (Pat. & Baker) Gilbert, Bolets, p. 108. 1931.
Boletus retisporus Pat. & Baker, Journ. Straits Branch R. Asiatic Soc. No. 78: 72. 1918.

This Singapore species is extremely interesting, and easily identified by the combination of yellow hymenophore and short, reticulate spores. I have studied the type specimen in the Patouillard Herbarium (FH). The spores are asymmetrical, brown, the ridges forming the complete and conspicuous network are 1.3–2 μ high, but often half or entirely imbedded in a colorless outer wall. My measurements are: 12–12.5 x 8–9.5 μ. Basidia 28 x 11 μ. Hyphae 5–12 μ thick in the trama, without clamp connections. The mycelium is white, and the pileus, though this is not mentioned in the original description, is distinctly appressed-squamulose.

Sect. **Chrysenteroidei** Sing. sect. nov.
Pileo haud roseo nec purpurascente nec carmineo, at flavo, fusco, castaneo; sporis longitudinaliter vittatis vel striatis, aut levibus, elongatis, aut latissimis (10.5–11 μ) aut moderate voluminosis (circa 12.5–17 μ longis); velo spurio vel nullo; pileo stipiteque haud viscidis; stipite haud ceraceo-lacunoso.

Characters of the section: see key (p. 107), and the above Latin diagnosis. The type species is *Boletellus chrysenteroides* (Snell) Snell.

KEY TO THE SPECIES

A. Spores consistently smooth. *Boletellus turbinatus*

A. Spores, at least their overwhelming majority, ridged because of longitudinal lamellose wings.

B. Wings of the spores striped transversely by low veins, or, at least, the bases of the wings connected by such transversal veins, giving the spores an appearance reminiscent of the ornamentation of the spores in *Boletellus ananas*.
Boletellus chrysenteroides

B. Wings not connected nor striped by regular transversal veins.

C. Pores discolorous, not yellow to melleous as the tubes, but red.

D. Spores 15.5–17 x 10.5–11 μ, with the lamellose wings projecting 1–1.7 μ.
Boletellus Linderi

D. Spores 12.5–15.2 x 6.5–7 μ; wings lower than 1 μ.
6. *Boletellus pictiformis*

C. Pores concolorous, yellow or melleous.

E. Spores (12.2)–13–13.8–(15.3) x (5.5)–6–(6.8) μ. *Boletellus pictiformis* var. *fallax*

E. Spores 14–22.5 x 6.5–10 μ (compare *B. chrysenteroides*, if collected on the North American Continent, and *B. guadelupensis* if collected in the West Indies).

DESCRIPTION OF THE SPECIES OCCURRING IN FLORIDA

6. **Boletellus pictiformis** (Murr.) Sing. comb. nov. var. *typicus*.
Suillellus pictiformis Murr., Lloydia **6** (3): 226. 1943.

Pileus castaneous, densely shaggy-tomentose, convex, 40–60 mm. broad. — *Hymenophore* yellow or melleous with red pores, changing at once to cyaneous when wounded, plane pores 1 mm. in diameter. — *Stipe* lateritious above, castaneous below, very shaggy, sulphureous at the apex, enlarged upward, 60–80 x 10–13 mm. — *Context* citrinous, yellow, turning blue at once; taste mild or acid. (Macroscopical description drawn from W. A. Murrill's notes.)

Spores 12.5–15.2 x 6.5–7 μ, intensely melleous, subfusoid, with longitudinal ridges from the tip downward to the hilar tube, the ridges occasionally anastomosing or forking, but their sides and the space between them not veined transversely; *basidia* 27–34 x 11.5–14.2 μ, 4-spored; *cystidia* clavate-mucronate, or fusoid-ventricose with a cylindric ampullaceous neck which sometimes is curved, or merely fusoid with obtuse apex, hyaline, or with a melleous belt-like incrustation; *terminal hyphae* of the tomentum of the pileus melleous, clavate, 82 x 10.8 μ, the lower hyphae 4–14 μ in diameter, without clamp connections.

Habitat: On banks under trees. July to August.

Distribution: North Florida.

Material studied: Kelley's Hammock, Alachua Co., *Murrill* (FLAS, **type**); also authentic material from Sanchez and Planera Hammock, Alachua Co., *Murrill F 17945*, *F 17862* (FLAS).

The type variety is evidently very rare even in the large hammock region northwest of Gainesville where it has been found exclusively. It is so rare indeed that W. A. Murrill has collected it only four times since 1938, and I was not able to gather specimens during my stay in Gainesville. It is remarkable because of its relation with an African species, *B. Linderi*. These species are very similar in many regards and are no doubt closely related. It is interesting to find two species with striking affinities at two isolated points on opposite sides of the Atlantic. *B. pictiformis* may well be derived from forms with African ancestry, but it would be dangerous to generalize concerning this probability for all Strobilomycetaceae of this hemisphere, since *B. ananas* and *B. porphyrius*, *Porphyrellus subflavidus*, *P. malaccensis* and *P. lacunosus*, and also *Boletellus jalapensis* show quite different geographic relationships, extending rather across the Pacific than across the Atlantic.

Boletellus pictiformis (Murr.) Sing. var. **fallax** Sing. var. nov.
A typo differt poris concoloribus cystidiisque paucis incrustatis.

Pileus brown because of the "Prout's brown," "mummy brown," or "bister" appressed fibrose scales with the pale yellow flesh showing through between them, not viscid, convex, without or with only slightly projecting margin, 42–53 mm. broad. — *Hymenophore* "yellowish citrine" to "olive lake" when mature, with concolorous pores which are angular and number 5–10 per 5 mm. transversely, and individually 0.3–1.5 mm. in diameter, i.e. rather large when quite mature, the tubes somewhat depressed around the stipe, moderately long (5–7 mm.), turning blue on injury. — *Stipe* below "mummy brown," in the middle "madder brown" to "Vandyke brown," or paler and with yellow shining through, and at the apex "Pinard yellow," fibrous-scaly-shaggy in the color of the pileus, the scales often arranged in a coarsely reticulate manner, solid, equal, with acuminate-tapering base, 60 x 12–13 mm. — *Context* of the pileus yellow, richer yellow at the apex of the stipe ("baryta yellow" to "empire yellow"), between "bay" and blackish brown at the base, strongly and readily turning blue in the pileus when cut, rather thick in the pileus; odor and taste not remarkable.

Spores (12.2)–13–13.7–(15.3) x (5.5)–6–(6.8) μ, deep melleous, with low to medium high longitudinal lamellose wings which are not connected by regular transverse veins, but occasionally by oblique anastomoses of the wings which are often forked, with suprahilar depression or applanation, ellipsoid-fusoid; *basidia* 4-spored, 25–39 x 12–13.7 μ; *cystidia* numerous near pores, mostly ampullaceous, pale melleous to hyaline, not incrusted or occasionally somewhat incrusted, (23)–38–60 x 10–14.2 μ; also some extremely versiform cheilocystidia are present at the very edge of the tube walls; *cuticle* of the pileus made up of repent or obliquely ascending strands of parallel, cylindric hyphae with the second-last member always elongate and 4–10 μ thick, the terminal member cylindric with rounded ends and as long as the other hyphae, or shorter, with some rare spherocysts on the very surface.

Chemical reactions: **KOH** on the surface of the pileus eventually deep reddish brown; on tubes and context ochraceous brown. — **NH_4OH** on the surface of the pileus black; on the tubes and on the context negative, or removing the blue stain when applied after autoxydation has taken place. — **HNO_3** on the surface of the pileus rufous; on the context pale reddish-brown. — **$FeSO_4$** on the surface of the pileus negative; on the context negative, or removing the blue stain if applied after the autoxydation has taken place. — **Formol** on the context provoking more blue coloration.

Habitat: Under mixed hardwoods, in a mesophytic hammock. July.

Distribution: North Florida.

Material studied: Kelley's Hammock, N. W. of Gainesville, Alachua Co., July 14, 1943, *Singer F 2716* (FH).

This variety lacks the most characteristic feature of the type, and Murrill did not recognize it as his species when he saw it in fresh condition.

However, the complete identity of the anatomical characters and the fact that the type of var. *typicus* and the type of var. *fallax* were found in the same hammock, and also the agreement of the important macroscopical characters, makes it impossible to consider the variety as a separate species. I have called it var. *fallax* because it suggests other species rather than *B. pictiformis*, e.g. *Boletellus chrysenteroides* (Snell) Snell which, however, has not a floccose-fibrillose-squamose stipe, but only shows furfuraceous punctations. Its spores usually have distinct transverse, regular anastomosing veins between the wings, reminding one of the ornamentation of *B. ananas*. Nothing like this is seen in spores of *B. pictiformis* var. *fallax*. The cuticle of *B. chrysenteroides* and *B. pictiformis* var. *fallax* also are very different in structure.

EXTRALIMITAL SPECIES

Boletellus chrysenteroides (Snell) Snell, Mycologia **33:** 422. 1941.
Boletus chrysenteroides Snell, Mycologia **28:** 468. 1936.

This has been described from New York, but additional material has been found in the Farlow Herbarium from Glenbrook Ravine, northeast Georgia, A. B. Seymour, det. W. H. Snell (*B. fumosipes*), and there is material in E. V. Seeler's Herbarium, collected by him on Nantucket, Mass., det. D. H. Linder & R. Singer. W. H. Snell was kind enough to send me his entire material, including specimens from North Carolina, West Virginia, Tennessee, Missouri, and Pennsylvania, all the same species with the covering of the pileus like that of *Porphyrellus pseudoscaber*, and actually with the same type of structure, but of a different brown. The spores are somewhat variable from specimen to specimen, (9.5)–11–17.3–(18.2) x 5.8–9.8 μ, with longitudinal lamellose wings of 0.6–0.8 μ height, melleous, the wings connected by regular, transverse veins recalling those of *Boletellus ananas* but not always running all through and up the sides of the wings reaching their edges; basidia 4-spored, 25–39 x 11–19 μ; cystidia fusoid to ampullaceous, hyaline or pale melleous, not incrusted, numerous on and near the pores, 34–62 x 9.5–18.5 μ; trama initially truly bilateral (*Boletus*-type), later more regular; epicutis formed by a palisade of erect, septate hyphae, with the last members conic-fusoid or cylindric, the second-last ones conic-obtuse or like the lower ones, i.e. almost as broad as long and rather voluminous, fulvous brown; they measure: last member 17–18 x 5.8–9.8 μ, second 17–18 x 13–17 μ below, and 7–11 μ above, third and following members 17–18 x 13–17 μ; hyphae without clamp connections.

One of the specimens, a co-type of Snell's, collected at Burnet, Quebec, Canada, differs from all other specimens in having the longitudinal wings of the spores more frequently anastomosing, or even with transverse ridges, but not always showing the characteristic thin, low veins found in the type; these spores are a trifle larger, 13–18.7–(20) x 7.3–9.2–(10.2) μ, and thus are intermediate between *B. chrysenteroides* and *B. guadelupensis*; their wings are 0.8–0.9 μ high, some lower. The external appearance of the fruit

bodies is nearly the same as in the type, but they are larger in all parts. Since two small characters are coupled in this case, distinguishing the northernmost collection from all the rest, one may suspect that the Canadian form is a geographic race. Further observations on this subject are needed. *B. chrysenteroides* is apparently the northern equivalent of the Floridian *B. pictiformis*.

Boletellus Linderi Sing. spec. nov.

PLATE I, FIG. 10.

Pileo flavo ("Naples yellow" Ridgway), fibrillulis squamulisque badiocastaneis ("mahogany red" Ridgway) dense obtecto, (25)–60 mm. lato; hymenophoro poris primum rubris et aequalibus, deinde aurantiacis et irregularibus instructo, e tubulis longis consistente; sporis ellipsoideis, brunneis, 17–23–alatis, ornamentatione 0.9–1.7 μ alta, polo apicali levi, 15.5–17 x 10.5–11 μ metientibus; basidiis 34 x 14.7 μ, clavatis, tetrasporis; cystidiis circa 63 x 22 μ, ventricoso-ampullaceis; stipite ad apicem luteo ("light cadmium" Ridgway) et atro-squamoso, fibroso, elongato; carne fracta caerulescente. Habitatio: Ad folia delapsa ad basin arboris Augusto mense. In Liberia Africae Occidentalis, prope Miamu. *D. H. Linder 408* (FH).

Boletellus turbinatus (Snell) Sing. comb. nov.

PLATE I, FIG. 3.

The type from Missouri (FH) shows the spores to be deep honey color with a fulvous tinge in the episporium, smooth but thick walled, the apical portion attenuate and mostly subacute, often with an incomplete germinative pore. These are typical *Boletellus*-spores in spite of their being smooth. I found them 13.5–20 x 5.5–9.5 μ; Snell finds them up to 21 μ long. I suspect that the turbinate habit is merely incidental.

SPECIES IMPERFECTLY KNOWN

Boletus chrysenteron Bull. *sensu* Coker & Beers, The Boletaceae, p. 70, *pl. 44* (below), *pl. 64, fig. 8.* 1943 (*non* Fr.).

Discovered in North Carolina, this species agrees with the preceding one in many ways, but differs in the more truncate apex of the spores and the spore measurements as given by Coker and Beers. Material from Chapel Hill, however, has the spores larger than given by these authors, viz. (11.5)–13–17–(26) x 4.8–6.5 μ. This cannot be Bulliard's plant, since species with spore characters like those described and figured by Coker and Beers do not occur in the environs of Paris. It is also not Fries's *Boletus chrysenteron* which equals *Boletus communis* Bull. *sensu* Coker & Beers (*l.c.*, p. 62). This latter name can not be accepted according to the rules of nomenclature. If *Boletus chrysenteron sensu* Coker & Beers should turn out to be different from *Boletellus turbinatus*, it must be renamed. However, we are inclined to think that the turbinate shape of the latter is an accidental character of no taxonomic value and little if any constancy; consequently these species may be synonymous.

Sect. **Ixocephali** Sing. sect. nov.

Superficiebus sterilibus carpophororum plus minusve viscidis; sporis longitudinaliter vittatis; stipite haud subceraceo-lacunoso.

Characters of the section: see key (p. 107) and Latin description above. The type, *Boletellus singaporensis* (Pat. & Baker) Gilbert (*Boletopsis singaporensis* Pat. & Bak.), has a distinct annulus, but I think that evelate forms like *Boletellus jalapensis* are close enough to be placed in this same section. The section *Ixocephali* is not represented in Florida.

Boletellus singaporensis (Pat. & Baker) Gilbert, Bolets, p. 107. 1931.
Boletopsis singaporensis Pat. & Baker, Journ. Straits Branch R. Asiatic Soc. No. 78: 69. 1918.

The species has a beautiful, distinct, tardily lacerate annulus which is said to be viscid in fresh condition. The type (FH) shows a pretty species with long stipe and thick hymenophore, well agreeing with the original description. The spores are comparatively short, 14–15 x 10.5–12.5 μ, with about 13 longitudinal wing-like lamellose ridges which are brown on melleous ground, and 1.2–1.6 μ high, and suddenly cut off at the apex, with a globose oil-drop and asymmetrically inserted hilar tube, some of the ridges not reaching the opposite end, not transversely veined, wall 0.8–1.1 μ thick; basidia 23–27 x 15–17 μ; cystidia subulate-fusoid with rounded tips, 45 x 10.5 μ. This species, under a temporary herbarium name, is represented in Patouillard's Herbarium (*#4992*).

Boletellus jalapensis (Murr.) Gilbert, Bolets, p. 107. 1931.
Ceriomyces jalapensis Murr., Mycologia **2:** 248. 1910.

The type (NY) from Mexico has 16–18–(25) x 10–11–(13.5) μ large, deep melleous spores with 10–14 longitudinal ribs with scarce anastomoses but usually once or twice forked ribs among them, the ribs 1–1.5 μ high; basidia 38–42 x 14–15.5 μ, 4-spored; cystidia not found but probably present; hyphae without clamp connections; structure of the cuticle of the pileus not clear, hyphae clampless, elongate, some claviform, some very thin, yellowish-subhyaline, of variable diameter.

I have not seen the material determined as *Boletogaster jalapensis* by Lohwag but judging from the picture and the description, it may be a long-stemmed form of this species. This would extend the area of *B. jalapensis* to South China, another indication of the close relationship between the boletineous flora of North and Central America and Eastern Asia. It may, however, turn out that Lohwag's determination was only approximate, and that the Chinese fungus is a third species of this section characterized by its stipe which is twice as long as in typical *B. jalapensis*. As for the description of the ornamentation of the spores, I am not sure that Lohwag's observations are quite exact. If they are, it would indicate an additional difference between this and the Chinese species. The spores of the Mexican type have the projecting angles (corresponding to the ribs) when seen from above, *not* semicircular but lamellose-rectangular, thinner than the distance

they project from the surface of the wall proper, and their number, when counted at one of the poles never reaches twenty.

Sect. **Dictyopodes** Sing. sect. nov.

Pileo tomentoso, haud viscido; sporis longitudinaliter costato-vittatis, elongatis; stipite subceraceo-lacunoso et ex ea re reticulato vel longitudinaliter lamellato.

Characters of the section: see key (p. 107) and the above Latin diagnosis. The type species is *Boletellus Russellii* (Frost) Gilbert (*Boletus Russellii* Frost).

7. **Boletellus Russellii** (Frost) Gilbert, Bolets, p. 107. 1931.
Boletus Russellii Frost, Bull. Buffalo Soc. Nat. Hist. **2:** 104. 1874.
Ceriomyces Russellii Murr., Mycologia **1:** 144. 1909.
Boletogaster Russellii Lohwag *in* Handel-Mazzetti, Symb. Sin. **2:** 56. 1937.
Frostiella Russellii Murr., Mimeogr. Contr. Herb. Univ. Fla. Agr. Exp. Sta. Gainesville, p. 6. 1942.

PLATE I, FIG. 9.

Pileus "Sayal brown" and "wood brown" mixed, later about "avellaneous," strongly tomentose, becoming strongly furfuraceous to felty-squamulose, dry or scarcely subviscid after prolonged rains, with smooth margin which strongly projects beyond the hymenophore, appearing lobate or crenate from above, pulvinate, 35–80 mm. broad. — *Hymenophore* "naphthaline yellow," becoming "barium yellow" to "strontian yellow," pores concolorous but with a slight pinkish hue when young, surrounded by the sterile projecting margin which is pallid and reddening, tubes medium long, 5–9 mm., adnate, becoming depressed around the stipe when mature, pores rather small to medium wide, widest in the marginal row, 3 per mm., then becoming wider, most frequently 0.8 mm. wide, but sometimes up to 1 mm. in diameter; spore print "dark olive." — *Stipe* "cacao brown" to "walnut brown," at least above, the ribs and mostly also the entire base "vinaceous pink" to "buff pink," with very high (about 2–3 mm.) lamellose longitudinal ribs which strongly anastomose, making the surface appear conspicuously lacunose-favose, the single honeycomb of varying length (1–10 mm.), the base usually smooth but often covered with white to whitish yellow mycelial felt, solid, becoming slightly hollow, slightly to strongly viscid outside, especially below, tapering at the base into the ground, and also tapering upward in the upper one or two thirds, or thickened at the base and gradually tapering to the apex, the basal portion usually covered by rotten leaves, 63–80 x 14–20 mm. — *Context* whitish to creamy pallid, stramineous-pallid, becoming eventually melleous in the base of the stipe, and reddish under the cuticle, more so when wounded, eventually almost "walnut brown" in the upper portion of the pileus, almost unchanging on injury, rather hard in the stipe but the consistency of the ribs almost waxy, soft-fleshy in the pileus; taste mild; odor almost none, eventually slightly mawkish.

Spores 16–19.5 x 8–11 μ, melleous, ornamentation and wall brown, with longitudinal, wing-like, lamellose ridges which run from the apical pole to

the hilar tube, suddenly stopping at the apex, without the transverse veins of *Boletellus ananas*, occasionally some ridges connected by a few scattered anastomosing ridges, the longitudinal ridges numbering about 13 at the poles, and projecting 1.8–2.1 μ; *basidia* 25–35 x 13–16 μ, 4-spored; *cystidia* mostly fusoid-ampullaceous, often compressed, 45–70 x (6.5)–9.5–15 μ, occasionally with a colored incrustation but wall and contents always hyaline; *trama* of the hymenophore truly bilateral, mediostratum slightly darker and denser than the strongly diverging hyaline lateral stratum; *cuticle* of the pileus consisting of multi-septate, erect chains of hyphae with clampless septa, most members of these chains rather short to almost subglobose, but the terminal cell elongate (about 50 μ long), cylindric or subulate; surface layer of the stipe consisting of a palisade of dermatocystidia and abundant dermatopseudoparaphyses, also some basidia; the *dermatocystidia* of the young specimens hyaline to brown, ampullaceous, up to 80–100 x 10.8 μ; *dermatopseudoparaphyses* up to 11 μ broad; *basidia* 4-spored, about 46 x 13.2 μ; *hyphae* of the context without clamp connections.

Chemical reactions. **KOH** on the surface of the pileus chestnut or fulvous; on the context of the upper portion of the pileus brown; on the context of the stipe slowly brownish; **NH_4OH** on the surface of the pileus somewhat deeper and more brick colored; on the context of the upper portion of the pileus red; on the context of the stipe slowly reddish; **$FeSO_4$** on the surface of the pileus deep olive; on the context of the pileus and stipe negative; **formol** negative; **phenol** negative.

Habitat: Under oaks, in Florida under *Quercus laurifolia* in high hammock formations on the soil amongst leaves. Summer.

Distribution: All along the Atlantic Coast from New England to Central Florida and west to Wisconsin (according to Murrill) and Mississippi. In Florida not reaching the tropical part of the peninsula.

Material studied: **Fla.:** Alachua Co., in and near Gainesville, *R. Singer F 2500, F 2500a* (FH); Lake Co., Eustis, on wood of *Sabal, R. Thaxter* (FH); — **Vt.: type** of *Boletus Russellii*, Brattleboro, in damp woods, 1865, *C. C. Frost* (FH). — **N. H.:** Shelburne, Aug. 1891, *Farlow* ("form with scaly top") (FH); Chocorua, September 1917, *Farlow* (FH); Intervale, August 1901, *Thaxter 3473* (FH). — **Mass.:** Arlington, *H. M. N.* (FH): Middlesex Fells, August 1897, *Farlow* (FH); Canton, August 1925, *D. H. Linder* (FH). — **N. C.:** Glassy Mts., Flat Rock, August 1934, *A. S. Rhoads* (det. W. A. Murrill) *F 9385* (FLAS).

B. Russellii is unmistakable for anyone who has once collected it. Its history shows clearly that there was doubt about its specific taxonomy only once when Lloyd claimed its identity with *B. betula*, an error subsequently corrected by W. G. Farlow. There was, however, considerable fluctuation in its generic position. I cannot see any reason for splitting the genus *Boletellus* into several genera, but if it is done (which would make it necessary to go much farther in breaking up the genus than we do now in dividing the boletaceous genera and the agarics) it should be done according to the sections outlined in the key p. 107. However, *Frostiella* is not a

valid name since it has been published without a Latin diagnosis, and in the sense of Murrill covers several sections of *Boletellus*; thus it becomes a synonym of the older name *Boletogaster* Lohwag. There is a fine colored picture in *Icones Farlowianae, pl. 80*, and a good photograph has been published in Coker and Beers, *The Boletaceae, pl. 48*. MacIlvaine *pl. 118, fig. 2* is likewise correct. Elrod and Blanchard (Mycologia **31:** 701, *fig. 2, E.* 1939) published a photomicrograph showing the structure of the trama. The difference of the picture obtained as compared with our results is due to insufficient consistency on the part of these authors in their choice of corresponding and comparable stages of development. In young hymenophores, the trama of practically all Boletineae is more or less bilateral, and all Strobilomycetaceae have the truly bilateral trama of the *Boletus*-type.

SPECIES NOT KNOWN TO THE AUTHOR

Boletellus costatus (Rostrup) Sing., Ann. Myc. **40:** 18. 1942.
Boletus costatus Rostrup, Botan. Tidskr. **24:** 357. 1902.

Described from Thailand, tropical Asia, this probably belongs in this section.

Sect. **Allospori** Sing. sect. nov.

Pileo viscido; sporis spinis exosporio immersis ornatis; stipite subceraceo-lacunoso et ex ea re reticulato vel longitudinaliter lamellato.

Characters of the section: see key p. 107, and Latin diagnosis above. The type species, *B. betula* (Schw.) Gilbert, is so far the only species of this section. It has not been found in Florida.

Boletellus betula (Schw.) Gilbert, Bolets, p. 108. 1931.

A North American species, reported from many eastern and middle western states, has also been called *Ceriomyces betula* Murr., *Frostiella betula* Murr., and *Boletus Morgani* Peck. It was initially described as *Boletus betula* by Schweinitz, Schr. Naturf. Ges. Leipzig **1:** 90. 1822. I have studied specimens from several localities, and the results of my microscopical analyses follow:

Spores 16–21.5 x 8.5–10 μ, deep ochraceous-melleous, with suprahilar applanation, ellipsoid-fusoid, with isolated punctiform warts if the upper surface of the spore is focussed upon, but actually the wall perforated by cylindric thin spines which are darker than the wall and hardly pass beyond its outer surface; basidia 25–40 x 11.6–16.5 μ, 4-spored; cystidia present; the pellicle consists of a palisade of dermatocystidia (100 x 8 μ) and more basidium-like bodies; the surface of the stipe consists of a palisade of sterile elements.

SPECIES INCERTAE SEDIS

Strobilomyces paradoxus Mass., Bull. Misc. Inf. Bot. Gard. Kew **1909** (5): 209. 1909.
Boletellus paradoxus Gilbert, Bolets, p. 107. 1931.

This species has been described from Singapore. I have seen no specimens.

Boletus Rostrupii Syd., Ann. Myc. **1:** 177. 1903.
Boletus lacunosus Rostr., Bot. Tidskrift, **24:** 357. 1902 (non Cooke).

This species has been described from Thailand. I have seen no specimens but it seems reasonable to assume that it belongs in the Strobilomycetaceae.

Strobilomyces fasciculatus Cooke, Grevillea **20:** 4. 1891.

This species from Australia may or may not belong in the Strobilomycetaceae. No specimens have been examined by the writer.

Strobilomyces ligulatus Cooke, Grevillea **20:** 4. 1891.
Boletellus ligulatus Sing., Ann. Myc. **40:** 18. 1942.

Described from Australia, this seems to be a *Boletellus*, provided the description is correct. However, the spore ornamentation (if there is any) has not been mentioned by Cooke.

Strobilomyces rufescens Cooke & Mass., Grevillea **18:** 5. 1889.

The description of this Australian species reads much like that of *Strobilomyces pallescens* which is a synonym of *Boletellus ananas*.

Boletellus pustulatus (Beeli) Gilbert, Bolets, p. 107. 1931.
Boletus pustulatus Beeli, Bull. Soc. Roy. Bot. Belg. **58:** 211. 1926.

Described from Belgian Congo, this species has been transferred by Gilbert to *Boletellus*, and, judging from the original description, correctly so. If the spores actually are as small as indicated by Beeli, one would expect this species to belong in the section *Chrysenteroidei*, though its color is more suggestive of section *Ananae*.

Phyllobolites Sing., Ann. Myc. **40:** 59. 1942.

No representatives occur in Florida.

HARVARD UNIVERSITY
CAMBRIDGE, MASS.

EXPLANATION OF PLATE I

All drawings are made with the aid of a camera lucida from dried material mounted in KOH-phloxine (basidia and cystidia) or either ammonium hydroxide or Melzer's reagent (spores) under oil immersion lens. Magnification approximately x 1050.

1. *Strobilomyces confusus* Sing. Spores, basidium; from the type specimen.
2. *Strobilomyces floccopus* (Vahl ex Fr.) Sacc. Spores, basidium; specimen from Harvard, Mass.
3. *Boletellus turbinatus* (Snell) Sing. Spores, basidium; from the type specimen.
4. *Porphyrellus subflavidus* (Murr.) Sing. Spores; from authentic material.
5. *Porphyrellus gracilis* (Peck) Sing. Spores, basidium; from authentic material.
6. *Strobilomyces velutipes* Cooke. Spores, basidium; from the type material.
7. *Boletellus ananas* (Curt.) Murr. Spores, basidium; specimen from North Florida.
8. *Strobilomyces pterosporus* Sing. Spores, basidium; from the type specimen.
9. *Boletellus Russellii* (Frost) Gilb. Spores, basidia and cystidia.
10. *Boletellus Linderi* Sing. Spores, basidium; from the type specimen.

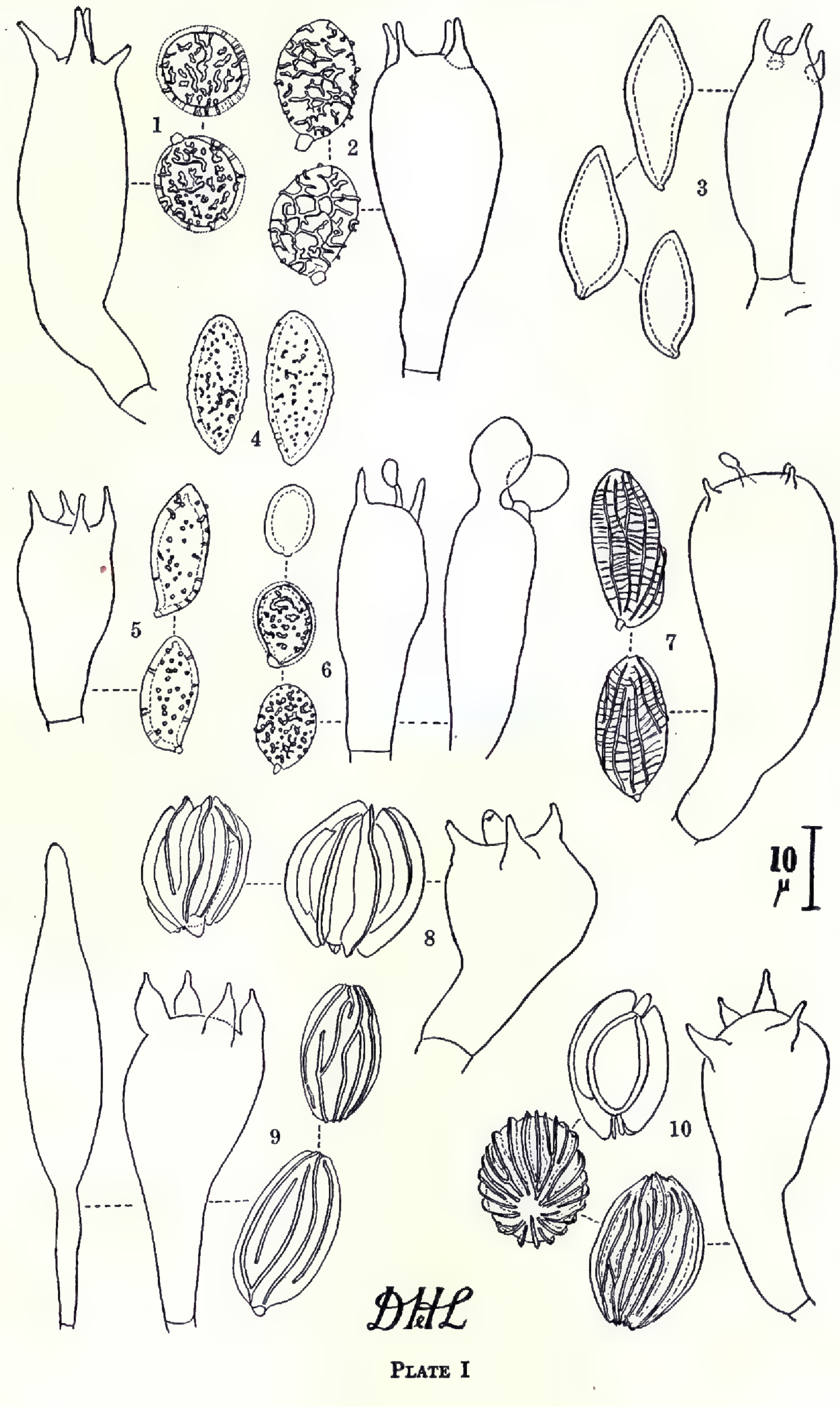

PLATE I

MANUSCRIPT

Contributions from anyone will be considered, preference being given to papers dealing with phases of the taxonomy of the Fungi, Algae, Musci, Hepaticae, and Lichens.

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Writers are responsible for the accuracy of references to literature cited and to text illustrations. Papers containing lists of citations and descriptions of species should maintain a uniform and orderly arrangement of the parts of such citations, etc.

Manuscripts must be typewritten, double spaced throughout, with a 1¼ inch margin on the left, on white paper, preferably 8½ x 11 inches.

Because of the cost of reproducing photographs, carefully made line drawings in black ink are preferred. For the same reason, as many figures as are consistent with clarity should be grouped together to make up a plate. Numerous small figures in the text are to be avoided. Photographs, when necessary, should be printed on glossy, contrast paper and planned for reproduction as full page plates 4¼ x 7 inches, the standard size for all plates. Avoid combining line drawings with photographs.

To comply with the International Rules, Latin descriptions must be supplied to validate new species and genera.

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Vol. 2 JULY, 1945 No. 2

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CONTENTS OF VOL. 2, NO. 2

A Taxonomic and Ecological Study of Some Diatoms from the Pocono Plateau and Adjacent Regions. By *Ruth Patrick* 143

The Boletineae of Florida with Notes on Extralimital Species. II. The Boletaceae (Gyroporoideae). By *Rolf Singer* 223

Vol. 2, No. 1, was issued March 22, 1945.

ERRATA

In **Patrick: Pocono Diatoms.** *Farlowia 2(2), July, 1945.*

On p. 166, l. 17, heading *ACHNANTHES subgenus* should read *ACHNANTHIDIUM subgenus.*

On p. 187, l. 5 of key, *PARALLELESTRIAE* should read *PARALLELISTRIATAE.*

FARLOWIA

A JOURNAL OF CRYPTOGAMIC BOTANY

VOL. 2 JULY, 1945 NO. 2

A TAXONOMIC AND ECOLOGICAL STUDY OF SOME DIATOMS FROM THE POCONO PLATEAU AND ADJACENT REGIONS

RUTH PATRICK

The Pocono plateau, which is located in the northeastern section of Pennsylvania, is part of the general Appalachian system. Geologically it is mostly sandstone of the Pocono and Catskill formation which was laid down in the late Devonian and early Carboniferous times. Here and there are present local limestone outcrops.

In this study the diatoms were obtained from regions adjacent to as well as in the Pocono plateau. Various types of bodies of water in Carbon, Lackawanna, Luzerne, Monroe, Northampton, Pike, and Wayne County were included. Thus localities on the Martensburg shale, Helderberg, and Chemung formations were also studied.

In this region there are many so-called lakes. From the limnological standpoint these are not lakes but ponds, for they have no thermocline. They are formed in one of two ways; either they are of glacial origin or are dammed up streams. Immediately after the Civil War there was much lumbering in this region. The dams were constructed in the streams to form storage basins for the logs until the spring thaws. At that time they would be floated down stream. After these lumbering operations had ceased these ponds were used as a source of ice. During the winter, ice would be cut and stored in ice houses which were built on the shores of the ponds. With the advent of artificial ice, this business ceased and summer resorts were built about the ponds.

A description of the various localities from which the diatoms were collected is given below. The ecological information concerning these habitats is to be found in the ecological discussion.

LACKAWANNA COUNTY

2044 Indian Lake, from squeezings of surface vegetation, *Hodge*, 7 July 1941

LUZERNE COUNTY

2042 Harvey Lake, from squeezings of the bottom vegetation, in quiet shallow water, *Hodge*, 7 July 1941

2043 Harvey Lake, from squeezings of vegetation in running water at the outlet, *Hodge*, 7 July 1941

MONROE COUNTY

Pocono Lake, a composite collection made by *Mr. F. J. Myers* during the summer of 1940.

262 Jaggie's Bog, *Shulze*

263 Jaggie's Bog, *Shulze*

2010 South Pocono Lake, in a small bay one foot deep, on rocks and on moss and weeds growing on bottom, *Patrick*, 8 July 1941

2011 South Pocono Lake, squeezings from *Sphagnum* in 18 inches of water, *Patrick*, 8 July 1941

2012 A small stream from springs, running under road to Davy's Run, shallow, filled with *Sphagnum*, *Patrick*, 8 July 1941

2013 Shallow ditch along road to Davy's Run, very cold, in shade, *Patrick*, 9 July 1941

2014 Davy's Run, beaver dam, surface mud and scum around weeds, growing in 3–4 inches of water, *Patrick*, 9 July 1941

2015 Davy's Run, in running water below beaver dam, attached or enmeshed in *Fontinalis antipyretica*, *Patrick*, 9 July 1941

2016 Davy's Run, surface ooze in 3–4 inches of water, about 50 feet above beaver dam in shade, *Patrick*, 9 July 1941

2017 Davy's Run, open sun, running water, on or enmeshed in weeds, *Patrick*, 9 July 1941

2018 Davy's Run, deep shade, surface of mud, still, shallow water, *Patrick*, 9 July 1941

2019 Davy's Run, deep shade, rapid water, squeezings from *Hypnum* and *Fontinalis*, *Patrick*, 9 July 1941

2020 Lost Lake, squeezings from *Sphagnum*, *A. Turner*, 5 July 1941

2025 Raymondskill Falls, surface scum on rocks in pool in falls, *Patrick*, 2 July 1941

2031 Mud Run, squeezings from moss in spillway, *Hodge*, July 1941

2032 Tobyhanna Creek, shallow water near flat rocks on side of creek known as "Lover's Leap", *Patrick*, 8 July 1941

2033 Tobyhanna Creek, near bank of creek, *Patrick*, 8 July 1941

2034 Pocono Lake, on stones in 1 foot of water at Emlen dock, *Patrick*, 30 June 1941

2035 Pocono Lake, from squeezings of *Elodea*, *Dicranium*, and *Hypnum* growing in 1 foot of water at Emlen dock, *Patrick*, 30 June 1941

2036 Pocono Lake, from squeezings of *Myriophyllum* in 2 feet of water at Emlen dock, *Patrick*, 30 June 1941

2037 Spring run near Emlen cottage, squeezings from weeds, *C. Myers*, 6 July 1941

2038 Pocono Lake, plankton taken by tow net, *Patrick and Hodge*, 7 July 1941

2039 Lake Tamaque, surface scum, *Hodge*, 7 July 1941

2040 Lake Tamaque, scrapings from log, *Hodge*, 7 July 1941

2045 Popomoning Lake, from squeezings of *Elodea*, *Hodge*, July 1941

2046 Wier Lake, squeezings from surface vegetation, *Hodge*, July 1941

2047 Wier Lake, squeezings from bottom vegetation, *Hodge*, July 1941

2049 Trout Lake, squeezings from *Spirogyra*, *Hodge*, July 1941

2051 Mountain Lake, from squeezings of surface vegetation, *Hodge*, July 1941

2056 Davy's Run, full sun, in running water, enmeshed in *Fontinalis antipyretica*, *Patrick*, 8 July 1941

2065 Pocono Lake, scrapings from logs supporting Emlen's dock, *Patrick*, 10 July 1941

NORTHAMPTON COUNTY

2050 Green Pond, from squeezings of vegetation, *Hodge*, July 1941

PIKE COUNTY

1 Greeley, squeezings from *Fontinalis* in brook running through swamp, *J. Burke*, 4 July 1941

2 Greeley, squeezings from *Sphagnum* in swamp, *J. Burke*, 4 July 1941

3 Shohola Falls, from algae at top of falls, *J. Burke*, 4 July 1941

4 Shohola Falls, from moss at top of falls, in swift water, *J. Burke*, 6 July 1941
5 Lake Wallenpaupek tributary passing under Route 507, *J. Burke*, 5 July 1941
7–9 Shohola Falls, scrapings from dripping rock face, side wall of gorge, above concrete bridge crossing road below falls, *J. Burke*, 5 July 1941
10 Shohola Falls, from algae in brook at head of falls near pond, *J. Burke*, 6 July 1941
11 Shohola Falls, from moss in brook above falls, near pond, *J. Burke*, 6 July 1941
12 Shohola Falls, edge of pond above falls, *J. Burke*, 6 July 1941
13 Shohola Falls, scrapings from dripping wall in small glen at head of falls, *J. Burke*, 6 July 1941
14 Shohola Falls, scrapings from face of rock at side of falls, *J. Burke*, July 1941
15 Shohola Falls, gelatinous algae on rock wall facing falls, *J. Burke*, 6 July 1941
127–130 *J. Shulze* (no other information except Pike County given)
1621–1623 Bushkill Creek, in spring opposite head of island, *J. Shulze*. (I cannot be sure whether this locality is in Pike or Monroe county.)
2188–90 *J. Shulze* (no other information except Pike County given)

WAYNE COUNTY

2021 Angels, Mill Creek, in cool, shallow, swift water on rocks in middle of creek, *J. Burke and R. Patrick*, 5 July 1941
2022 Angels, small tributary of Mill Creek, deep shade, slow running, 2–5 inches deep, *J. Burke and R. Patrick*, 5 July 1941
2023 Angels, Mill Creek tributary, deep shade, from surface of leaves in spring bubbling through sand, *J. Burke and R. Patrick*, 5 July 1941
2024 Angels, scraping from surface of leaves in a very shallow pool or puddle, *J. Burke and R. Patrick*, 5 July 1941
2026 Angels, Mill Creek, full sun, growing on stones in swift, shallow water, *R. Patrick and J. Burke*, 5 July 1941

In this study it was thought wise to consider all obtainable collections that had ever been made in this region. Some of these collections are quite old and no information is available concerning the ecological conditions which existed when the collections were made. Because of this most of the ecological studies are based on a few of the most diversified ponds which were selected for this purpose. Much of the ecological data was obtained by Mr. Frank J. Myers who studied the rotifers present in these bodies of water (Proc. Acad. Nat. Sci. Phila. **94:** 251–286. 1942). The information concerning the calcium, bicarbonates, and color of the water was furnished by Dr. Thomas Edmondson, Woods Hole Oceanographic Laboratories.

In the study of all collections, hyrax mounts were made and the species identified were ringed by means of a diamond marker. In the taxonomic discussion under each species the localities are given in which the species were found and the number in parenthesis indicates the slide in the herbarium of the Academy of Natural Sciences of Philadelphia on which the identification was made.

The materials prepared for the ecological studies were made from a quantitative standpoint. The original amount of material collected in each case was as nearly as possible the same. If collections were made for epiphytic diatoms, one-half pint (236 c.c.) of weeds or debris was collected and squeezed. The drippings were retained and concentrated, and one half of this concentrate was cleaned. The cleaned material in each case was diluted

to a common dilution factor. This solution was then well shaken and immediately one tenth of a cubic centimeter was withdrawn and deposited on a cover glass. Methods comparable to these were also used for the planktonic and encrusted forms.

In this study five terms have been used to denote the relative abundance of the species found. The slides, with the aid of a mechanical stage, were methodically studied. In most cases a 3 mm. objective was used in making these counts. However, when large forms were being studied a 16 mm. objective was used. "Rare" indicates that only a very few specimens were found on the slides studied. "Frequent" indicates that one or two specimens were present in about fifty per cent of the fields of the microscope. "Very frequent" indicates that an average of two or three specimens were found in each field. "Common or abundant" indicates that several specimens were found in each field.

The author is particularly indebted to Mr. Frank J. Myers who furnished much valuable information which he had obtained concerning these bodies of water, and who also made available the equipment of his summer laboratory at Pocono Lake Preserve. The author also wishes to express her appreciation to Dr. Thomas S. Stewart who made the photographs included in the plates; to Dr. Thomas Edmondson who made the chemical analysis of the water; to Miss Jane Stenz who made the slides for this study; to Mr. Joseph Burke who made available his collections from Pike County; to Dr. Francis W. Pennell for his help with Latin descriptions; and to Miss Hilda F. Harris of the Farlow Herbarium, to Mrs. Gertrude Hess of the library of the American Philosophical Society, and to Mr. Frank Patrick who made available additional literature necessary for this study.

MELOSIRA AGARDH

A. Sulcus absent, in girdle view frustule very finely striated ... **M. varians**

A. Sulcus present

  B. Sulcus a distinct concave throat or channel

    C. Lives in running water on rocks or in moss; in valve view, puncta arranged in definitely radiating rows ..... **M. roeseana** and var.

    C. Typically a pelagic form ..... **M. ambigua**

  B. Sulcus a narrow groove ..... **M. italica**

Melosira ambigua Müller, 1905, Bot. Jahrb. Syst. Pflanzengesch. u. Pflanzengeog. **34:** 283. *pl. 4, figs. 9, 10.*

For a discussion of this species see my paper in Proceedings of the Academy of Natural Sciences of Philadelphia **92:** 195. 1941.

This species was very frequent in a gathering made by Shulze in Pike County. Unfortunately we have no habitat data concerning this collection. Krieger (1929) states it is found in waters with a pH of 5.5–7.8.

Monroe County: Pocono Lake Preserve, Pocono Lake, 2036 *Patrick* (A-2148), 2038 *Patrick* (A-2152); Tobyhanna Creek, 2033 *Patrick* (A-2142); Trout Lake, 2047 *Hodge* (A-2172). Pike County: 127–128 *Shulze* (A-2215–17).

Melosira italica (Ehr.) Kütz., 1844, Bacill., p. 55. *pl. 2, fig. 6.*
Gaillonella italica Ehr., 1836, Ber. K. Akad. Wiss. Berlin **1836:** 53.

This species was common in the pond above Shohola Falls.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131); Jaggie's Bog, 262 *Shulze* (A-2223). Pike County: 130 *Shulze* (A-2221); Shohola Falls, 10–11 *Burke* (A-2201–02), 12 *Burke* (A-2204), 14 *Burke* (A-2209).

Melosira roeseana Rabh., 1852, Algarum Europaea no. 382, 1853, Sussw. Diat., p. 13. *pl. 10, suppl. fig. 5.*

It is hard for me to be sure of the difference between *M. roeseana* and *M. roeseana* v. *epidendron*. I have checked my specimens with those of Rabenhorst's on Rabh. Alg. Sach. Resp. Mitteleurop. no. 383 and with Van Heurck's Type Slide no. 465. I find that *M. roeseana* on these slides has the ridges, perhaps spines, on the margins of the valve arranged at regular intervals, usually between each stria. In *Melosira roeseana* v. *epidendron* according to Van Heurck's figure (Syn. Diat. Belgique, *pl. 89, figs. 17–18*) and in Van Heurck's Type Slide no. 467 the spines are irregularly arranged. Also the structure of variety *epidendron* seems to be somewhat coarser.

This species was present only in the locality given below.

Pike County: Shohola Falls, 15 *Burke* (A-2211).

Melosira roeseana v. **epidendron** (Ehr.) Grun. *apud* Van Heurck, 1882, Syn. Diat. Belgique, *pl. 89, figs. 17, 18.*
Sphenosira epidendron Ehr., 1848, Ber. K. Akad. Wiss. Berlin **1848:** 219.

In collection no. 7 of Burke were found specimens which differ in number of striae in 10 μ from the figure in Van Heurck's Synopsis Diatomées Belgique. In girdle view the striae are 17–18 in 10 μ instead of 14 in 10 μ.

This variety was of frequent occurrence in the collections cited.

Pike County: Shohola Falls, 7–9 *Burke* (A-2196–98).

Melosira varians Ag., 1827, Flora (Bot. Zeit.) **10** (2): 628.

This species though present in two habitats was not of frequent occurrence in either.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Shohola Falls, 4 *Burke* (A-2192).

CYCLOTELLA KÜTZING

A. Valves circular, center of valve marked by radiating lines producing a star-shaped pattern ..... **C. stelligera**

A. Center of valve otherwise marked or clear

  B. Marginal striae interspersed with thickenings, middle field of valve filled with radiating punctae ..... **C. comta v. radiosa**

  B. Marginal striae without such thickenings **C. Meneghiniana v. rectangulata**

Cyclotella comta v. **radiosa** Grun. *apud* Van Heurck, 1882, Syn. Diat. Belgique, *pl. 92, fig. 23*, text (1885) p. 214.

Though only found in one habitat it was common there. Hustedt states that it is especially found in sub-alpine lakes. It seems to be found most commonly in this country in habitats north of or above the frost line.

Luzerne County: Harvey Lake, 2042–43 *Hodge* (A-2160–63).

Cyclotella Meneghiniana v. **rectangulata** Grun. *apud* Van Heurck, 1882, Syn. Diat. Belgique, *pl. 94, figs. 17–19.*

Pike County: Shohola Falls, 4 *Burke* (A-2192), 10–11 *Burke* (A-2200–02).

Cyclotella stelligera (Cl. and Grun.) Van Heurck, 1882, Syn. Diat. Belgique, *pl. 94, figs. 22-27.*

Cyclotella Meneghiniana v. ? *stelligera* Cl. and Grun. *apud* Cl., 1881, K. Sv. Vet. Akad. Handl. **18** (5): 22.

This species was found only once and then it was rare.

Monroe County: Trout Lake, 2049 *Hodge* (A-2174).

ODONTIDIUM KÜTZING EMEND. BESSEY

Odontidium anceps Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 127.

This species was rare in several localities. It was common in very shallow water, on the surface of leaves at Angels, Wayne County. The temperature of the water was between 50–60° F.

Pike County: 2188–90 *Shulze* (A-2234–36), 128 *Shulze* (A-2217); Lake Wallenpaupek tributary, 5 *Burke* (A-2195). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123), 2023–24 *Burke and Patrick* (A-2127–29).

Odontidium hiemale v. **mesodon** (Ehr.) Grun., 1862, Verh. Zool. Bot. Ges. Wien **12:** 357.

Fragilaria mesodon Ehr., 1839, Abhandl. K. Akad. Wiss. Berlin **1838:** 57. *pl. 2, fig. 9.*

This variety was very frequent in shallow running water at Angels, and in squeezings from the bottom vegetation of shallow water in Wier Lake.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131); Wier Lake, 2046–47 *Hodge* (A-2169–70). Pike County: 127 *Shulze* (A-2215); Lake Wallenpaupek Tributary, 5 *Burke* (A-2195); Shohola Falls, 15 *Burke* (A-2211). Wayne County: Angels, 2021–24 *Burke and Patrick* (A-2123–29), 2026 *Burke and Patrick* (A-2134).

TABELLARIA EHRENBERG

Tabellaria fenestrata (Lyngb.) Kütz., 1844, Bacill., p. 127. *pl. 17, fig. 22; pl. 18, fig. 2; pl. 30, fig. 73.*

Diatoma fenestratum Lyngbye, 1819, Tent. Hydrophyt. Danicae, p. 180. *pl. 61, fig. 3.*

From this study it would seem that this species preferred shallow water. It is of very frequent or common occurrence in Mud Run, Pocono Lake, Tobyhanna Creek and the pond above Shohola Falls, in scrapings from dripping rocks.

Lackawanna County: Indian Lake, 2044 *Hodge* (A-2164). Luzerne County: Harvey Lake, 2042 *Hodge* (A-2161). Monroe County: Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138); Pocono Lake, 2034–36 *Patrick* (A-2144–48), 2038 *Patrick* (A-2152), 2065 *Patrick* (A-2182), *F. Myers* (A-2213); South Pocono Lake, 2010–11 *Patrick* (A-2101–04); Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); Lake Tamaque, 2039 *Hodge* (A-2154); Wier Lake, 2046 *Hodge* (A-2168). Pike County: 2188–90 *Shulze* (A-2233–36), 127–30 *Shulze* (A-2215–21); Greeley, 1 *Burke* (A-2184); Shohola Falls, 10–14 *Burke* (A-2201–10).

Tabellaria flocculosa (Roth) Kütz., 1844, Bacill., p. 127. *pl. 17, fig. 21.*

Conferva flocculosa Roth, 1797, Catalecta Botanica Fasc. 1, p. 192. *pl. 4, fig. 4; pl. 5, fig. 6.* (This reference was checked for me by Miss Harris of the Farlow Library.)

This species was very frequent or common in Pocono Lake, Mud Run, Tobyhanna Creek, Davy's Run and Shohola Falls. It seems to prefer somewhat more acid conditions than the preceding species and is often found associated with moss. Krieger (1929) states it prefers pH 3.5–5.5.

Monroe County: Davy's Run, 2014–19 *Patrick* (A-2109–19), 2056 *Patrick* (A-2180); Jaggie's Bog, 262 *Shulze* (A-2223); Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138); Pocono Lake, 2034–36 *Patrick* (A-2144–48), 2038 *Patrick* (A-2152), 2065 *Patrick* (A-2182), *F. Myers* (A-2213); Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); South Pocono Lake, 2010 *Patrick* (A-2102); Popomoning Lake, 2045 *Hodge* (A-2166); Raymondskill Falls, 2025 *Patrick* (A-2131); Trout Lake, 2049 *Hodge* (A-2174); Wier Lake, 2047 *Hodge* (A-2170). Pike County: 2188–89 *Shulze* (A-2233–35); Bushkill Creek, 1621–23 *Shulze* (A-2227–31); Greeley, 1–2 *Burke* (A-2184–88); Shohola Falls, 3–4 *Burke* (A-2190–92), 10–14 *Burke* (A-2200–10). Wayne County: Angels, 2021 *Burke and Patrick* (A-2124).

MERIDION AGARDH

Meridion circulare (Grev.) Ag., 1831, Consp. Crit. Diat., p. 40.

Echinella circulare Grev., 1822, Mem. Werner. Nat. Hist. Soc. **4** (1): 213–15. *pl. 8, fig. 2.*

The specimens most commonly found in this study differ from the type in having the apex or head end of the valve acute instead of rounded. This species reached its best development in shallow, flowing, somewhat acid waters; — in a tributary of Mill Creek, in a brook running through a swamp at Greeley, at Jaggie's Bog, and at Shohola Falls.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2161). Monroe County: Davy's Run, 2014–15 *Patrick* (A-2109–11), 2018–19 *Patrick* (A-2117–19); Jaggie's Bog, 262 *Shulze* (A-2223); Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138); Tobyhanna Creek, 2033 *Patrick* (A-2142); Trout Lake, 2049 *Hodge* (A-2174); Wier Lake, 2046–47 *Hodge* (A-2169–70). Pike County: 128 *Shulze* (A-2217), 130 *Shulze* (A-2221); Bushkill Creek, 1621–23 *Shulze* (A-2227–31); Greeley, 1 *Burke* (A-2184); Shohola Falls,

3–4 *Burke* (A-2190–92), 10 *Burke* (A-2200), 14 *Burke* (A-2208). Wayne County: Angels, 2021–22 *Burke and Patrick* (A-2123–25), 2026 *Burke and Patrick* (A-2134).

Meridion circulare v. **constricta** (Ralfs) Van Heurck, 1881, Syn. Diat. Belgique, *pl. 51, figs. 14, 15*, text (1885) p. 161.

Meridion constrictum Ralfs, 1843, Ann. Mag. Nat. Hist. **12:** 458. *pl. 18, fig. 2.*

This variety was found most often in Wayne County. As contrasted with the species the only habitat in which it was very frequent was from scrapings of dead leaves in a small, very shallow puddle at Angels.

Monroe County: Davy's Run, 2016 *Patrick* (A-2113); Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: 127 *Shulze* (A-2215); Greeley, 2 *Burke* (A-2188); Shohola Falls, 11 *Burke* (A-2203), 12 *Burke* (A-2204). Wayne County: Angels, 2021–24 *Burke* (A-2124–29).

FRAGILARIA LYNGBYE

A. Valves united to each other at middle portion of valve, thus having the ends of the valve separate and free ..... **F. crotonensis**

A. Valves forming bands by other methods

B. Axial area linear and narrow, sometimes lacking or indistinct, central area lacking. See B′ and B″

C. Valve constricted at center ..... **F. undata v. lobata**

C. Valve not constricted

D. Valve elliptic or linear with rounded ends, striae about 11 in 10 μ ..... **F. pinnata**

D. Valve linear or lanceolate in shape, striae more numerous

E. Valve capitate

F. Some of the striae not opposite each other on either side of the pseudoraphe thus producing an irregular effect ..... **F. bicapitata**

F. Striae regular, not as above .. **F. virescens** var.

E. Valve not capitate ..... **F. virescens**

B′. Axial area linear and narrow, central area present

G. Central area bilateral, valve constricted in the middle **F. capucina** var.

G. Central area unilateral, valve swollen on one side **F. Vaucheriae**

B″. Axial area more or less lanceolate, wider at center than at ends of valve

H. Striae very coarse, 6–8 in 10 μ ..... **F. leptostauron**

H. Striae much finer, 14–17 in 10 μ

I. Striae marginal

J. Valve elliptical ..... **F. elliptica**

J. Valve lanceolate with rostrate ends . **F. brevistriata**

I. Striae longer, valves linear or lanceolate ... **F. construens**

Fragilaria bicapitata A. Mayer, 1917, Denks. K. Bayer. Bot. Ges. **13:** n.s. **7:** 21. *pl. 1, fig. 26.*

This species was only once of very frequent occurrence and that was in

Wier Lake in association with bottom vegetation in shallow water. The pH was 6.6.

Monroe County: Wier Lake, 2046–47 *Hodge* (A-2169–70).

Fragilaria brevistriata Grun. *apud* Van Heurck, 1881, Syn. Diat. Belgique, *pl. 45, fig. 32*, text (1885) p. 157.

This species was rare in the two localities in which it was found.

Monroe County: Wier Lake, 2046 *Hodge* (A-2169).

Fragilaria capucina v. **mesolepta** Rabh., 1864, Flora Europaea Algarum, p. 118.

This variety was rare in the localities given below.

Monroe County: Popomoning Lake, 2045 *Hodge* (A-2166); Mountain Lake, 2051 *Hodge* (A-2178). Pike County: 2189 *Shulze* (A-2235), 128 *Shulze* (A-2217).

Fragilaria construens (Ehr.) Grun., 1862, Verh. Zool. Bot. Ges. Wien **12:** 371. *pl. 7, fig. 10.*

Staurosira construens Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin, **1841:** 424.

This species was found only in Pocono Lake, and then it was rare.

Monroe County: Pocono Lake Preserve, Pocono Lake, 2034 *Patrick* (A-2144), 2035 *Patrick* (A-2146), *F. Myers* (A-2213).

Fragilaria crotonensis Kitton, 1869, Science Gossip **1869:** 110. *fig. 81.*

This species was very frequent in one locality. It was probably washed into the brook from the lake.

Pike County: Shohola Falls, 10 *Burke* (A-2200).

Fragilaria elliptica Schuman, 1867, Schrift. Phys. Ökon. Ges. Königsburg **8:** 52. *pl. 1, fig. 5.*

This species was common in one collection: squeezings from littoral bottom vegetation in Lake Wier.

Monroe County: Wier Lake, 2047 *Hodge* (A-2170). Pike County: tributary of Lake Wallenpaupek, 5 *Burke* (A-2195).

Fragilaria leptostauron (Ehr.) Hustedt, 1931, in Rabenhorst's Krypt.-Flora, **7**(2): 153. *fig. 668a-f.*

Biblarium leptostauron Ehr., 1854, Mikrogeologie, *pl. 5, fig. II, 24, pl. 12, figs. 35, 36.*

This species was rare in the three habitats.

Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195). Wayne County: Angels, 2021–22 *Burke and Patrick* (A-2124–25).

Fragilaria pinnata Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 415.

This species was rare in occurrence.

Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195).

Fragilaria undata v. **lobata** var. nov.

Valvae constrictae ad medium, longae 20–54 μ, apicibus porrectis, pseudoraphe nulla, striis transversis tenuibus 16–17 in 10 μ.

William Smith (Ann. Mag. Nat. Hist. 2d ser. **15:** 7. *pl. 1, fig. 7*) first refers to this variety as *F. undata* v. γ. What may be this variety, though we cannot be sure as only the outline is shown and Ehrenberg questions it being in the genus *Fragilaria*, is given as *F. constricta* Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 415. *pl. 1, fig. I, 21; pl. 3, fig. VI, 10.* Hustedt has placed in synonymy the specimens of W. Smith under Ehrenberg's name, *Fragilaria constricta*, and has clearly stated in his description that there are horns or spines on the margins of the valve. He has cited as reference Tempère and Peragallo, 2d Ed. Diatomées du Monde Entier nos. 831, 868, 907, 939. I have checked these slides and also one from Christiana (Febiger 3437) which may be one of W. Smith's collections. In none of these specimens do I find any evidence of spines. It is true that on two specimens from Pocono Lake I saw evidence of spines, but this condition seems to be the exception rather than the rule.

Since Ehrenberg clearly indicates that he is doubtful about placing his species in the genus *Fragilaria* and also since one cannot be sure from his short description just what he had, I believe it best to make this form a variety of W. Smith's *F. undata.* The specimens of W. Smith which he considered typical for *F. undata* are very different from the figures of Ehrenberg for *F. constricta.*

Monroe County: Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213). Pike County: Shohola Falls, 13–14 *Burke* (A-2206–09).

Fragilaria Vaucheriae (Kütz.) Boye, 1938, Bot. Not. **1938**(1–3): 164–71.

Exilaria Vaucheriae Kütz., 1833, Linnaea **8:** 560. *pl. 15, fig. 38*; Kütz. Dec. no. 24.

Though found in several habitats this species was frequent in none.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Davy's Run, 2018 *Patrick* (A-2118); Trout Lake, 2049 *Hodge* (A-2174); Wier Lake, 2047 *Hodge* (A-2170). Pike County: Shohola Falls, 3 *Burke* (A-2190), 11 *Burke* (A-2202). Wayne County: Angels, 2026 *Burke and Patrick* (A-2134).

Fragilaria virescens Ralfs, 1843, Ann. Mag. Nat. Hist. **12:** 110. *pl. 2, fig. 6.*

This species was very frequent in squeezings from *Hypnum* and *Fontinalis* in Davy's Run, from the swamp at Greeley, from surface of dead leaves in shallow water at Angels, and from a locality of Shulze which was merely designated as Pike County.

Monroe County: Davy's Run, 2014 *Patrick* (A-2110), 2016–19 *Patrick* (A-2113–19), 2056 *Patrick* (A-2180); Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138); Pocono Lake, 2037 *Patrick* (A-2150), *F. Myers* (A-2213); Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42). Pike County: 2188–90 *Shulze* (A-2233–36); 127–130 *Shulze* (A-2215–21); Bushkill Creek, 1621 *Shulze* (A-2227); Greeley, 1 *Burke* (A-2184); Shohola Falls, 14 *Burke* (A-2208–10). Wayne County: Angels, 2024 *Burke and Patrick* (A-2129), 2026 *Burke and Patrick* (A-2134).

Fragilaria virescens v. **capitata** Oestrup, 1910, Danske Diat., p. 193. *pl. 5, fig. 125.*

In Jaggie's Bog this variety was very frequent.

Monroe County: Jaggie's Bog, 262 *Shulze* (A-2223); Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213). Pike County: 128 *Shulze* (A-2217). Wayne County: Angels, 2024 *Burke and Patrick* (A-2129).

ASTERIONELLA HASSALL

Asterionella formosa Hassall, 1855, Microscopical Examination of Water, p. 10. (As stated in previous papers I have been unable to verify this reference.)

This species reaches its best development in eutrophic water, though, as seen from this study, it can grow in slightly distrophic water but does not flourish so abundantly.

Luzerne County: Harvey Lake, 2042–43 *Hodge* (A-2161–62). Monroe County: South Pocono Lake, 2010 *Patrick* (A-2102); Tobyhanna Creek, 2033 *Patrick* (A-2142); Pocono Lake, 2034–36 *Patrick* (A-2144–49), 2038 *Patrick* (A-2152); Trout Lake, 2049 *Hodge* (A-2175).

Asterionella Ralfsii W. Sm., 1856, Brit. Diat., **2:** 81.

This species, unlike the one above, seems from this study to have its best development in strongly distrophic, acid water. It reaches its best development in Lake Tamaque with a pH of 3.8, and is frequent in Lost Lake.

Monroe County: Lost Lake, 2020 *Turner* (A-2121); Lake Tamaque, 2039 *Hodge* (A-2154). Pike County: Shohola Falls, 14 *Burke* (A-2210).

SYNEDRA EHRENBERG

A. Striae typically 15 or more in 10 μ, often small diatoms with rather delicate structure
  B. Ratio of breadth to length 1:11 or greater ..... **S. minuscula**
  B. Ratio of breadth to length less than above, central area distinct, often the valve slightly swollen at the central area ..... **S. rumpens** and vars.

A. Striae less than 15 in 10 μ
  C. Central area usually broader than long, striae 12 or less in 10 μ **S. ulna** and vars.
  C. Central area longer than broad, striae 12–14 in 10 μ, sometimes appearing very delicate ..... **S. acus** and vars.

Synedra acus Kütz., 1844, Bacill., p. 68. *pl. 15, fig. 7.*

This species was frequent among the moss growing at the top of Shohola Falls in swift water. This is evidently not the most desirable habitat for this species.

Pike County: Shohola Falls, 4 *Burke* (A-2192), 10 *Burke* (A-2201).

Synedra acus v. **delicatissima** (W. Sm.) Grun. *apud* Van Heurck, 1885, Syn. Diat. Belgique, p. 151.

Synedra delicatissima W. Sm., 1853, Brit. Diat., **1:** 72.

In W. Smith's original description he states that this diatom may vary from 130 to 220 μ (he gives it in terms of inches).

This variety was frequent in the surface water of Mountain Lake, pH 7.3.

Monroe County: Popomoning Lake, 2045 *Hodge* (A-2166); Mountain Lake, 2051 *Hodge* (A-2178).

Synedra minuscula Grun. *apud* Van Heurck, 1881, Syn. Diat. Belgique, *pl. 39, fig. 13.*

Though found in several habitats this species was of frequent occurrence in none.

Monroe County: Davy's Run, 2014 *Patrick* (A-2110), 2017 *Patrick* (A-2115), 2019 *Patrick* (A-2119), 2056 *Patrick* (A-2180); Pocono Lake Preserve, Tobyhanna Creek, 2032 *Patrick* (A-2140); Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195); Shohola Falls, 4 *Burke* (A-2192), 10–11 *Burke* (A-2200–02), 13–14 *Burke* (A-2206–08). Wayne County: Angels, 2022 *Burke and Patrick* (A-2125), 2026 *Burke and Patrick* (A-2134).

Synedra rumpens Kütz., 1844, Bacill., p. 69. *pl. 16, fig. VI, 4, 5.*

Though found in several habitats this species was always rare.

Monroe County: Davy's Run, 2019 *Patrick* (A-2119); Mountain Lake, 2051 *Hodge* (A-2178); Raymondskill Falls, 2025 *Patrick* (A-2131); Trout Lake, 2049 *Hodge* (A-2175). Pike County: Shohola Falls, 3–4 *Burke* (A-2190–92), 10 *Burke* (A-2200). Wayne County: Angels, 2021 *Burke and Patrick* (A-2124).

Synedra rumpens v. **familiaris** (Kütz.) Grun. *apud* Van Heurck, 1881, Syn. Diat. Belgique, *pl. 40, figs. 15, 16.* (Grunow questions whether this should be a variety.)
Synedra familiaris Kütz., 1844, Bacill., p. 68, *pl. 15, fig. 12.*

Monroe County: Wier Lake, 2046–47 *Hodge* (A-2169–70). Wayne County: Angels, 2026 *Burke and Patrick* (A-2134).

Synedra rumpens v. **scotica** Grun. *apud* Van Heurck, 1881, Syn. Diat. Belgique, *pl. 40, fig. 11.*

Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

Synedra ulna (Nitzsch) Ehr., 1832, Abhandl. K. Akad. Wiss. Berlin **1831:** 87.
Bacillaria ulna Nitzsch, 1817, N. Schrift. Naturf. Ges. Halle **3**(1): 99.

In these collections were found specimens which agree with *S. ulna* in regard to number of striae and the ratio between length and breadth but which had a central area which was longer than broad, as found in *S. acus.*

This species was common in the squeezings from surface vegetation of Wier Lake.

Monroe County: Mountain Lake, 2051 *Hodge* (A-2178); Raymondskill Falls, 2025 *Patrick* (A-2131); Wier Lake, 2046 *Hodge* (A-2169). Pike County: 127 *Shulze* (A-2215); Bushkill Creek, 1623 *Shulze* (A-2231); Lake Wallenpaupek tributary, 5 *Burke* (A-2195). Wayne County: Angels, 2022 *Burke and Patrick* (A-2125), 2026 *Burke and Patrick* (A-2134).

Synedra ulna v. **danica** (Kütz.) Van Heurck, 1881, Syn. Diat. Belgique, *pl. 38, fig. 14a*, text (1885) p. 151.

Synedra danica Kütz., 1844, Bacill., p. 66. *pl. 14, fig. 13.*

This variety was very frequent in Mountain Lake, a shallow tributary of Mill Creek, and at Shohola Falls. It is often a plankton form and it is unusual to find it so well developed in running water.

Monroe County: Mountain Lake, 2051 *Hodge* (A-2178); Popomoning Lake, 2045 *Hodge* (A-2166). Pike County: 2188–89 *Shulze* (A-2233–35); Bushkill Creek, 1621–23 *Shulze* (A-2227–31); Shohola Falls, 3–4 *Burke* (A-2190–92), 10–14 *Burke* (A-2200–10). Wayne County: Angels, 2022 *Burke and Patrick* (A-2125).

Synedra ulna v. **oxyrhynchus** (Kütz.) Van Heurck, 1885, Syn. Diat. Belgique, p. 151.

Synedra oxyrhynchus Kütz., 1844, Bacill., p. 66. *pl. 14, fig. 8, 2, IX–XI.*

This species was found only twice and then it was rare.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Wayne County: Angels, 2026 *Burke and Patrick* (A-2134).

Synedra ulna v. **Ramesii** (Herib. and Perag.) Hustedt *apud* Pascher, 1930, Süssw. Flora Mitteleurop. **10:** 152. *fig. 163.*

Synedra Ramesii Herib. and Perag., 1903, Diat. Foss. d'Auvergne, p. 80. *pl. 11, fig. 28.* (This reference was checked through the kindness of Miss Harris of the Farlow Library.)

This variety was only found once and then it was rare.

Wayne County: Angels, 2021 *Burke and Patrick* (A-2124).

EUNOTIA EHRENBERG

A. Dorsal and ventral margins of valve parallel or nearly so
  B. Valve with raphe extending backward from terminal nodules, a jelly pore present at one end of valve ..... **E. flexuosa**
  B. Valve not as above
    C. Valve strongly arcuate, spanning about 120° .. **E. elegans**
    C. Valves not so strongly arcuate
      D. Relatively large forms
        E. Ends of valve distinctly wider than rest of valve, somewhat wedge-shaped
          F. Valves slightly swollen in middle **E. formica**
          F. Valves not swollen in the middle **E. tautonensis**
        E. Ends of valve not distinctly wider than rest of valve, but capitate, striae coarse, 8–10 in 10 μ **E. monodon v. major**
      D. Relatively narrow forms
        G. Ends of valve distinctly capitate on dorsal margin, ventral margin flat. See G′ and G″.
          H. Valve arcuate

I. Striae 14–17 in 10 μ, terminal nodules small **E. lunaris v. capitata**

I. Striae 10–13 in 10 μ, terminal nodules large **E. gracilis**

I. Striae 12–14 in 10 μ, terminal nodules distinct but not large .**E. arcus v. curta**

H. Valve not arcuate, sometimes slightly curved, striae 12–15 in 10 μ .....**E. fallax**

G′. Ends of valve not capitate

J. Ends rounded, valve lunate in shape **E. lunaris**

J. Ends rounded, cell wall thick, valve only slightly arched .....**E. valida**

G″. Ends of valve narrowed and attenuate

K. Valve very narrow, striae 15–20 in 10 μ **E. Naegelii**

K. Breadth and length of valve variable, sometimes swollen at ends of valve, valves frequently occurring in long chains .....**E. pectinalis** and vars.

A. Dorsal margin smooth, convex, ventral margin straight or somewhat concave

L. Ends of valve distinctly set off from rest of valve

M. Typically large forms with coarse striae, not more than 12 in 10 μ

N. Valves with ventral margin straight or only slightly concave, ends of valve formed by a distinct narrowing of the valve, ends truncate .....**E. praerupta** and vars.

N. Ends of valve somewhat arcuate

O. Ends slightly swollen to form rounded apices **E. monodon**

O. Ends distinctly capitate .....**E. indica**

M. Typically small forms, striae more than 15 in 10 μ

P. Dorsal margin only slightly convex, ends strongly capitate, usually as wide if not wider than main part of valve **E. exigua**

P. Dorsal margin strongly convex

Q. Ends of valve more or less capitate

R. Striae about 21 in 10 μ ...**E. Meisteri**

R. Striae 15–19 in 10 μ .....**E. septentrionalis**

Q. Ends of valve not capitate .....**E. rostellata**

L. Ends of valve not distinctly set off from rest of valve

S. Striae 16 or more in 10 μ

T. Dorsal margin of valve somewhat pointed in the middle, thus giving the margin a slightly wedged appearance **E. trinacria**

T. Dorsal margin of the valve smoothly convex, not as above **E. tenella**

S. Striae usually 15 or less in 10 μ

U. Ends of valve distinct from rest of valve, ends attenuate, rounded .....**E. sudetica**

U. Ends of valve not distinct from rest of valve

V. Ends of valve acute, giving a sharp pointed appearance to the ends of the valves, sometimes slightly rounded **E. veneris**

V. Ends of valve broadly rounded. . **E. faba**

A. Valve with dorsal margin with definite undulations

W. Valves small, two to five undulation on dorsal margin, striae about 18 in 10 μ ..... **E. microcephala**

W. Valves more robust, striae 15 or less in 10 μ

X. Ends of valve distinctly attenuate, undulations serrate, breadth of valve 7–11 μ. See X′ and X″. ..... **E. septena**

X′. Ventral margin almost straight, undulations on dorsal margin crenate, two in number

Y. Ends of valve distinctly truncate

Z. Undulations well developed .... **E. suecica**

Z. Undulations formed by a slight constriction in the dorsal margin ..... **E. praerupta v. bidens**

Y. Ends of valve not truncate, but rounded **E. diodon**

X″. Ventral margin more or less concave, undulations crenate, four or more ..... **E. robusta**

Eunotia arcus v. **curta** (Grun.) Schönf., 1906, p. 116.

Himantidium arcus v. *curtum* Grun., 1862, Verh. Zool. Bot. Ges. Wien **12:** 339. *pl. 6, fig. 16.*

The identity of these specimens has been checked with Van Heurck's Type Slide No. 268. My specimens vary in length, some of them being 30 μ long. The striae are 12 in 10 μ.

Monroe County: Jaggie's Bog, 262 *Shulze* (A-2223). Pike County: 127 *Shulze* (A-2215).

Eunotia diodon Ehr., 1837, Ber. K. Akad. Wiss. Berlin **1837:** 45.

This species, though found in several localities, was never represented by more than a few specimens. Hustedt states that it is typically found on bare rocks in Northern Europe, and also in damp moss. This corresponds to the type of habitat where it was found in this study.

Monroe County: Davy's Run, 2015 *Patrick* (A-2111), 2019 *Patrick* (A-2119). Pike County: 127–128 *Shulze* (A-2215–17); Bushkill Creek, 1621 *Shulze* (A-2227); Shohola Falls, 14 *Burke* (A-2208).

Eunotia elegans Oestrup, 1910, Danske Diat. p. 172. *pl. 5, fig. 105.*

I believe this is the first time this species has been recorded from North America. The length of the valve measuring along its curvature was 48.7 μ, the breadth was two μ. The striae were 24–25 in 10 μ. This species was found in one collection.

Pike County: Greeley, 2 *Burke* (A-2188).

Eunotia exigua (Breb.) Rabh., 1864, Flora Eur. Algarum, p. 73.

Himantidium exiguum Breb. *ex* Kütz., 1849, Spec. Algarum, p. 8.

This species was rare in all habitats. Krieger (1929) says it is found in pH 3.5–5.5, especially with *Sphagnum*.

Monroe County: Davy's Run, 2019 *Patrick* (A-2119). Pike County: 2188 *Shulze* (A-2234); Bushkill Creek, 1623 *Shulze* (A-2231).

Eunotia faba Ehr. *emend.* Van Heurck, 1881, Syn. Diat. Belgique, p. 143. *pl. 34, fig. 34.*
Eunotia faba Ehr., 1837, Ber. K. Akad. Wiss. Berlin, **1837:** 45.

In all three habitats, this species occurred in running water associated with *Fontinalis* or other plants living in water. It was rare in all habitats.

Monroe County: Davy's Run, 2017 *Patrick* (A-2115); Pocono Lake Preserve, Spring Run, 2037 *C. Myers* (A-2150). Pike County: Greeley, 1 *Burke* (A-2184).

Eunotia fallax A. Cl., 1895, Bihang K. Sv. Vet. Akad. Handl. **21** (3) no. 2: 33. *pl. 1, fig. 35.*

Monroe County: Tobyhanna Creek, 2032 *Patrick* (A-2140).

Eunotia flexuosa Breb. *ex* Kütz., 1849, Spec. Algarum, p. 6.

The forms of this species found during this study were shorter and narrower than in typical specimens of the species. The ends were not inflated. I have carefully studied these forms and checked them with the isotype specimens in H. L. Smith, Spec. Typicae No. 555. These specimens differ a great deal from those which I found in my study of Brazilian diatoms, which have distinctly capitate ends.

The specimens were found in distinctly acid water. This species was of common occurrence in Bushkill Creek and at the edge of the pond at Shohola Falls.

Monroe County: Mountain Lake, 2051 *Hodge* (A-2178); Pocono Lake Preserve, Pocono Lake, 2035–36 *Patrick* (A-2146–49), 2039 *Patrick* (A-2154); Wier Lake, 2046 *Hodge* (A-2169); Lake Tamaque, 2039 *Hodge* (A-2154). Pike County: 130 *Shulze* (A-2221), 12 *Burke* (A-2204), 14 *Burke* (A-2210).

Eunotia formica Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 414.

This species was rare and may be a contamination.

Monroe County: Mountain Lake, 2051 *Hodge* (A-2178).

Eunotia gracilis (Ehr.) Rabh., 1864, Flora Europaea Algarum, p. 72.
Himantidium gracile Ehr. 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 417. *pl. 2, fig. I, 9; pl. 3, fig. I, 41.*

This species was found only once and then in small numbers.

Pike County: Greeley, *2 Burke* (A-2188).

Eunotia indica Grun. *apud* Rabh., 1865, Beitrage Näheren Kennt. und Verbreit. des Algen, **2:** 5. *pl. 1, fig. 7.*

This species though found only twice was of frequent occurrence at the spring on Bushkill Creek.

Monroe County: Pocono Lake Preserve, Pocono Lake, 2065 *Patrick* (A-2182). Pike County: Bushkill Creek, 1621 *Shulze* (A-2227).

Eunotia lunaris (Ehr.) Grun. *apud* Van Heurck, 1881, Syn. Diat. Belgique, *pl. 35, figs. 3, 4, 6.*

Synedra lunaris Ehr., 1832, Abhandl. K. Akad. Wiss. Berlin **1831:** 37.

This species is widely distributed. Its most favorable habitats are found in Pike County, particularly Bushkill Creek and Shohola Falls.

Luzerne County: Harvey Lake, 2043 *Hodge* (A-2162). Monroe County: Davy's Run, 2010 *Patrick* (A-2102), 2012–14 *Patrick* (A-2105–09), 2016 *Patrick* (A-2113), 2019 *Patrick* (A-2119); Jaggie's Bog, 262 *Shulze* (A-2223); Mountain Lake, 2051 *Hodge* (A-2178); Lake Tamaque, 2040 *Hodge* (A-2156); Wier Lake, 2046 *Hodge* (A-2168). Pike County: 127–128 *Shulze* (A-2215–17); 2188–90 *Shulze* (A-2233–36); Bushkill Creek, 1621–23 *Shulze* (A-2227–31); Greeley, 1–2 *Burke* (A-2184–88); Shohola Falls, 3–4 *Burke* (A-2190–92), 7 *Burke* (A-2197), 10–14 *Burke* (A-2200–08).

Eunotia lunaris v. **capitata** (Grun.) Hustedt *apud* Pascher, 1930, Süssw. Flora Mitteleurop., Heft 10: 185. *fig. 250.*

Synedra lunaris v. *capitata* Grun., 1862, Verh. Zool. Bot. Ges. Wien **12:** 389.

Pike County: Greeley, 2 *Burke* (A-2188); Bushkill Creek, 1621 *Shulze* (A-2227).

Eunotia Meisteri Hustedt *apud* Pascher, 1930, Süssw. Flora Mitteleurop. Heft 10: 179. *fig. 230.*

Though occurring in several different habitats, this species was only once very frequent and that was in association with *Hypnum* and *Fontinalis*, in Davy's Run.

Monroe County: Davy's Run, 2014–19 *Patrick* (A-2109–19), 2056 *Patrick* (A-2180); Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138); Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); Wier Lake, 2047 *Hodge* (A-2170). Pike County: Shohola Falls, 3 *Burke* (A-2190), 12–13 *Burke* (A-2205–06).

Eunotia microcephala Krasske, 1932, Hedwigia **72:** 102. *pl. 2, fig. 7.*

This is the same as Van Heurck's concept of *Eunotia tridentula* and *E. tridentula* v. *perminuta.* I have critically examined Van Heurck's Type Slides Nos. 309, 347, and his figures in Synopsis des Diatomées Belgique, *pl. 34, fig. 29, 30. Eunotia tridentula* was first described by Ehrenberg (Abhandl. K. Akad. Wiss. Berlin **1841:** 414. *pl. 2, fig. 1, 14*). From Ehrenberg's figure it is clear that it is a larger diatom than the one which Van Heurck had. Therefore Van Heurck's specimens should be considered a misidentification and Krasske's name should be adopted. This species was common in Spring Run.

Monroe County: Davy's Run, 2056 *Patrick* (A-2180); Pocono Lake Preserve, Tobyhanna Creek, 2033 *Patrick* (A-2142); Spring Run, 2037 *C. Myers* (A-2150).

Eunotia monodon Ehr., 1854, Mikrogeologie, *pl. 2, fig. II, 26 a. b.*

This species was only once of frequent occurrence and then in a spring in Bushkill Creek.

Monroe County: Wier Lake, 2046 *Hodge* (A-2169); Jaggie's Bog, 263 *Shulze* (A-2225). Pike County: 128 *Shulze* (A-2217); Bushkill Creek, 1621 *Shulze* (A-2227).

Eunotia monodon v. **major** (W. Sm.) Hustedt *apud* Pascher, 1930, Süssw. Flora Mitteleurop., Heft 10: 186.

Himantidium majus W. Sm., 1856, Brit. Diat., **2:** 14. *pl. 33, fig. 286.*

This species was present in several habitats, but was very frequent or common in only two, Wier Lake and Mountain Lake. In both instances it was found in association with surface littoral vegetation.

Monroe County: Davy's Run, 2056 *Patrick* (A-2180); Pocono Lake Preserve, Pocono Lake, 2035 *Patrick* (A-2146); Wier Lake, 2046 *Hodge* (A-2168); Mountain Lake, 2051 *Hodge* (A-2178). Pike County: 2188–90 *Shulze* (A-2234–36); Shohola Falls, 4 *Burke* (A-2192), 11–12 *Burke* (A-2202–04), 14 *Burke* (A-2209). Wayne County: Angels, 2023 *Burke* (A-2127).

Eunotia Naegelii Migula, 1907, Kryptogamen Flora, **2:** 203.

This species is sometimes called *Eunotia alpina* (Naeg.) Hustedt. The name *alpina* in the genus *Eunotia* is preoccupied by a species of Kützing, and therefore cannot be used for this species which when first named was in the genus *Synedra*.

From this study, it seems that this species prefers definitely distrophic, acid water. It was of very frequent occurrence in Lake Tamaque and Lost Lake.

Monroe County: Lost Lake, 2020 *Turner* (A-2121); Lake Tamaque, 2039–40 *Hodge* (A-2154–56). Pike County: Shohola Falls, 12 *Burke* (A-2205).

Eunotia pectinalis (Dillw.) Rabh., 1864, Flora Europea Algarum, p. 73.

Conferva pectinalis Dillw., 1809, Brit. Conf., p. 43. *pl. 24.*

From this study it seems that this species prefers moving water. It was very frequent in Davy's Run, at the spring in Bushkill Creek, and on dripping rocks at Shohola Falls.

Monroe County: Davy's Run, 2019 *Patrick* (A-2119), 2056 *Patrick* (A-2180); Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213); Tobyhanna Creek, 2032 *Patrick* (A-2140); Wier Lake, 2046 *Hodge* (A-2169). Pike County: 2188–90 *Shulze* (A-2233–36); Bushkill Creek, 1621 *Shulze* (A-2227); Shohola Falls, 3–4 *Burke* (A-2190–92), 14 *Burke* (A-2208).

Eunotia pectinalis v. **minor** (Kütz.) Rabh., 1864, Flora Europaea Algarum, p. 74.

Himantidium minus Kütz., 1844, Bacill. p. 39. *pl. 16, fig. 10, 1–4.*

Though found in several localities this species was very frequent only in Davy's Run.

Monroe County: Davy's Run, 2018–19 *Patrick* (A-2118–19), 2056 *Patrick* (A-2180); Lost Lake, 2025 *Turner* (A-2131); Pocono Lake Preserve, Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); Wier Lake, 2046 *Hodge* (A-2168); Mountain Lake, 2051 *Hodge* (A-2178). Pike County: 127 *Shulze* (A-2215); Bushkill Creek, 1623 *Shulze* (A-2231); Shohola Falls, 4 *Burke* (A-2192).

Eunotia pectinalis v. **minor** f. **impressa** (Ehr.) Hustedt *apud* Pascher, 1930, Süssw. Flora Mitteleurop., Heft 10: 182.

Eunotia impressa Ehr., 1854, Mikrogeologie, *pl. 3, fig. IV, 20; pl. 14, fig. 66.*

This form was very frequent in one locality designated as Pike County. Krieger (1929) states it is found in pH 4.5–5.5.

Monroe County: Pocono Lake Preserve, Spring Run, 2037 *Myers* (A-2150); Pocono Lake, 2038 *Patrick* (A-2152), 2065 *Patrick* (A-2182). Pike County: 2188–90 *Shulze* (A-2233–36); Bushkill Creek, 1623 *Shulze* (A-2231); Greeley, 1–2 *Burke* (A-2184–88); Lake Wallenpaupek tributary, 5 *Burke* (A-2195); Shohola Falls, 13 *Burke* (A-2206).

Eunotia pectinalis v. **recta** Rabh. *ex* Mayer, 1917, Denks. K. Bayer. Bot. Ges. **13** (n.s. **7**): *pl. 1, figs. 37, 38.*

Mayer gives no description and I have not been able to find the description of Rabenhorst. Therefore I am supplying the following Latin description.

Valvae lenes arcuatae 19–20 μ longae, 3 μ latae, apicibus linibus rotundis; striis 15–16 in 10 μ.

This variety was rare and found in only one locality.

Monroe County: Davy's Run, 2016 *Patrick* (A-2113).

Eunotia pectinalis v. **undulata** (Ralfs) Rabh., 1864, Flora Europaea Algarum, p. 74.

Fragilaria pectinalis v. *undulata* Ralfs, 1843, Ann. Mag. Nat. Hist. **12:** 108. *pl. 2, fig. 3d.*

Ralfs refers to Pritchard, 1841, A History of the Infusoria, p. 220. *fig. 171.* I have looked up this reference and find that the species being considered is listed under the name *Fragilaria grandis*.

This species though found in several habitats was common only in Bushkill Creek and at Shohola Falls from moss in swift water at the top and in scrapings from dripping rocks at Shohola Falls.

Monroe County: Davy's Run, 2016 *Patrick* (A-2113), 2019 *Patrick* (A-2119); Mountain Lake, 2051 *Hodge* (A-2178); Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138); Pocono Lake, 2034–36 *Patrick* (A-2144–48), 2038 *Patrick* (A-2152), 2065 *Patrick* (A-2182), *F. Myers* (A-2213); South Pocono Lake, 2010 *Patrick* (A-2101); Tobyhanna Creek, 2032 *Patrick* (A-2140). Pike County: 262 *Shulze* (A-2223); Bushkill Creek, 1621 *Shulze* (A-2227); Shohola Falls, 3 *Burke* (A-2190), 4 *Burke* (A-2193), 10 *Burke* (A-2200), 12 *Burke* (A-2204), 14 *Burke* (A-2210).

Eunotia praerupta Ehr., 1841, Ber. K. Akad. Wiss. Berlin **1841:** 143, 204.

This species was found only once and then it was rare.
Pike County: Greeley, 2 *Burke* (A-2188).

Eunotia praerupta v. **bidens** (Ehr.) Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 109.

Eunotia bidens Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 413.

Hustedt states that Ehrenberg's identification is doubtful, so he uses W. Smith's *Himantidium bidens* as the basis for the name *bidens*. W. Smith, however, gives Ehrenberg as the authority for the name *Himantidium bidens*, and refers to Kützing's "Species Algarum," p. 9. Kützing refers to Ehrenberg in Abhandl. K. Akad. Wiss. Berlin, **1841:** 413 where he states that *Himantidium bidens* equals *Eunotia bidens*, which is described in the reference given above.

This species was found only in Pike County. In the Greeley habitats it was associated with either *Fontinalis* or *Sphagnum*. In one collection, 2188 Shulze, specimens were found with spines on the dorsal margin of the valve.

Pike County: 129 *Shulze* (A-2219), 2188 *Shulze* (A-2234); Bushkill Creek, 1621 *Shulze* (A-2227); Greeley, 1–2 *Burke* (A-2184–88).

Eunotia praerupta v. **curta** Grun. *apud* Van Heurck, 1881, Syn. Diat. Belgique, *pl. 34, fig. 24.* (in the text, 1885, Van Heurck refers to this as forma *curta*).

This variety is rare in each of the localities.

Pike County: Greeley, 2 *Burke* (A-2188); Shohola Falls, 12 *Burke* (A-2204).

Eunotia praerupta v. **inflata** Grun. *apud* Van Heurck, 1881, Syn. Diat. Belgique, *pl. 34, fig. 17*, text (1885) p. 143.

Pike County: Greeley, 1 *Burke* (A-2184).

Eunotia robusta Ralfs *apud* Pritchard, 1861, A History of the Infusoria, p. 763.

Unless, as I have previously suggested, De Toni's "Sylloge Algarum" is taken as a starting point for diatoms, this name, according to the International Rules of Botanical Nomenclature section 10, article 56, will have to be discarded.

In this study, the species was typically found in acid water. It reached its best development in Lost Lake which is strongly distrophic, and in South Pocono Lake in association with *Sphagnum*.

Monroe County: Lost Lake, 2020 *Turner* (A-2121); Pocono Lake Preserve, South Pocono Lake, 2010–11 *Patrick* (A-2101–03); Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); Pocono Lake, 2034–35 *Patrick* (A-2144–47), 2065 *Patrick* (A-2182), *F. Myers* (A-2213). Pike County: 128–29 *Shulze* (A-2217–19), 2188–90 *Shulze* (A-2234–36); Bushkill Creek, 1621 *Shulze* (A-2227); Greeley, 1 *Burke* (A-2184); Shohola Falls, 12 *Burke* (A-2204).

Eunotia rostellata Hustedt. This species was invalidly described by Hustedt, 1913, in A. Schmidt's Atlas der Diatomaceen-Kunde, *pl. 289, figs. 3, 4.* I have therefore included a Latin description.

Valvae arcuatae 46 μ longae, 4–5 μ latae, dorsali et ventrali lateribus prope parallelis; striis 14–17 in 10 μ.

I have checked my specimens with those of H. L. Smith, Spec. Typicae no. 160 which are from the type locality, and they seem to be the same. The striae usually vary from 14–15 in 10 μ at the center of the valve to 17 in 10 μ at the ends.

Pike County: 2189 *Shulze* (A-2235).

Eunotia septena Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 414. *pl. 4, fig. II, 13.*

It would perhaps be wise to unite several of these species of Ehrenberg as Ralfs and Grunow have done. If this is done, however, according to the International Rules of Botanical Nomenclature, one of Ehrenberg's names must be retained, as any additional name would be superfluous.

This species was rare in one locality.

Pike County: 127–30 *Shulze* (A-2215–21).

Eunotia septentrionalis Oestrup, 1897, Meddl. om Grönld. **15:** 274. *pl. 1, fig. 10.*

This species occurred typically in acid water. It reached its best development in association with moss in running water and was very frequent in *Sphagnum* in the swamp at Greeley, and of frequent occurrence in Davy's Run and Mud Run.

Monroe County: Davy's Run, 2014 *Patrick* (A-2109), 2019 *Patrick* (A-2119); Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138). Pike County: 2188 *Shulze* (A-2233), 128 *Shulze* (A-2217); Greeley, 1–2 *Burke* (A-2184–88); Shohola Falls, 3 *Burke* (A-2190), 14 *Burke* (A-2208).

Eunotia sudetica O. Müll., 1898, Forschungsber. Biol. Stat. Plön **6:** 59. *pl. 3, figs. 25, 26.*

Monroe County: Wier Lake, 2046 *Hodge* (A-2168).

Eunotia suecica A. Cleve, 1895, Bihang K. Sv. Vet. Akad. Handl. **21** Afd. 3 (2): 29, *pl. 1, figs. 31, 32.*

This species occurred only once and then it was rare.

Pike County: Shohola Falls, 9 *Burke* (A-2198).

Eunotia tautonensis Hustedt.

This species, lacking any kind of description, is invalidly described by Hustedt, 1913, in A. Schmidt's Atlas Diatomaceen-Kunde, *pl. 291, figs. 1–3.*

Valvae arcuatae elongatae, 94–257 μ longae, 5–10 μ latae, lateribus parallelis, apicibus cuneatis; striis 12–17 in 10 μ.

As in *Eunotia flexuosa* the terminal nodules are distinct, and at one end of the valve there is a jelly pore. The striae vary from 12–14 in 10 μ in the center of the valve to 17 in 10 μ at the end of the valve. Some of the specimens from Lost Lake, where the species was very frequent, had small spines

on the dorsal margin. However, this was not typically the case. No doubt this species is near to the genus *Desmogonium*.

Monroe County: Lost Lake, 2020 *Turner* (A-2121); Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213).

Eunotia tenella (Grun.) Hustedt *apud* Pascher, 1930, Süssw. Flora Mitteleurop., Heft 10: 175. *fig. 220.*

Eunotia arcus v. *tenella* Grun. *apud* Van Heurck, 1881, Syn. Diat. Belgique, *pl. 34, figs. 5, 6.*

PLATE I, FIG. 1

This species was first invalidly described by Hustedt, 1913, A. Schmidt's Atlas Diatomaceen-Kunde, *pl. 287, figs. 20–25.*

A small form of this species which corresponds to Hustedt's illustration in A. Schmidt's Atlas Diatomaceen-Kunde, *pl. 287, fig. 25,* was also found. It is 9.3 μ long, 3.5 μ wide, and the striae are 17 in 10 μ. As it is quite different in shape from the usual *E. tenella,* I have illustrated it.

This species was very frequent in the swamp at Greeley.

Monroe County: Davy's Run, 2016 *Patrick* (A-2113), 2018–19 *Patrick* (A-2118–19); Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138). Pike County: 2188 *Shulze* (A-2234); Bushkill Creek, 1623 *Shulze* (A-2231); Greeley, 2 *Burke* (A-2188).

Eunotia trinacria Krasske, 1929, Bot. Arch. **27:** 349. *fig. 1.*

This species was present in only two habitats.

Monroe County: Davy's Run, 2017 *Patrick* (A-2115). Pike County: Greeley, 2 *Burke* (A-2188).

Eunotia valida Hustedt *apud* Pascher, 1930, Süssw. Flora Mitteleuropas. Heft 10: 178. *fig. 229.*

This species was rare in one habitat where it might have been a contamination from some other habitat.

Pike County: 130 *Shulze* (A-2221).

Eunotia veneris (Kütz.) De Toni, 1891, Sylloge Algarum, **2:** 794.

Himantidium veneris Kütz., 1844, Bacill. p. 40. *pl. 30, fig. 7.*

In 1854 Gregory (Quart. Jour. Micros. Sci. **2:** 96) describes a diatom which he states W. Smith has named *Eunotia incisa.* He states that he has sent some of these specimens to Kützing who replied that they were different from *Himantidium veneris.* Gregory further states that his species is very similar in shape to *H. veneris,* but that *H. veneris* does not have the notches close to the terminal puncta nor does it have striae as *Eunotia incisa* does. Obviously, if it belongs to the genus *Himantidium,* it has striae. As for the notches to which Gregory refers, they are the terminal nodules. I find that by careful focusing, this notch can be shown to appear and disappear. Unfortunately I have not seen any authenticated specimens of either Kützing or Gregory.

In some cases specimens were found with obtuse ends as Gregory shows as variety β. The striae in some of my specimens were coarser than is usually found in *E. veneris*. They were in some cases as few as 12 in 10 μ. Perhaps these forms should be separated as varieties.

This species was very frequent at Shohola Falls in a collection made from a dripping wall and in a collection from algae and moss in the brook. It was common in squeezings from plants (*Elodea*, *Myriophyllum*, etc.) in shallow water in Pocono Lake and Lake Popomoning, and in Spring Run.

It is interesting to note that this species reached such good development in two habitats which were quite diverse in some respects. Pocono Lake has an average pH of 6.4. Analysis of the water shows calcium 2.37 p.p.m., and bicarbonates 15.6 p.p.m. Popomoning Lake has a pH of 8–8.1, calcium 8.82 p.p.m., and bicarbonates 33.6–34.2 p.p.m. In Pocono Lake the specimens had rounded ends, and striae about 14 in 10 μ. In Lake Popomoning the specimens had acute apices and striae 17–20 in 10 μ. Krieger (1929) states that this species is found in pH 4.5–5.5, which is lower than either of these two habitats.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Davy's Run, 2015–16 *Patrick* (A-2111–13), 2018 *Patrick* (A-2118); Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138); Pocono Lake, 2034–37 *Patrick* (A-2144–50), 2065 *Patrick* (A-2182); Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); Popomoning Lake, 2045 *Hodge* (A-2166). Pike County: 2188 *Shulze* (A-2233); Bushkill Creek, 1623 *Shulze* (A-2231); Greeley, 2 *Burke* (A-2188); Shohola Falls, 3 *Burke* (A-2190), 10–14 *Burke* (A-2200–09). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

COCCONEIS (EHR.) CLEVE

Cocconeis placentula Ehr., 1838, Die Infusionsthierchen als volkommene Organismen, p. 194.

This species was of common or very frequent occurrence at Raymondskill Falls, Harvey Lake, Popomoning Lake, and Mountain Lake.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131); Popomoning Lake, 2045 *Hodge* (A-2166); Mountain Lake, 2051 *Hodge* (A-2178). Northampton County: Green Pond, 2050 *Hodge* (A-2177). Pike County: Shohola Falls, 10–11 *Burke* (A-2201–02); Lake Wallenpaupek tributary, 5 *Burke* (A-2195); Bushkill Creek, 1623 *Shulze* (A-2231). Wayne County: Angels, 2021–22 *Burke and Patrick* (A-2124–25).

Cocconeis placentula v. **lineata** (Ehr.) Cl., 1895, K. Sv. Vet. Akad. Handl. **27** (3): 169.

Cocconeis lineata Ehr. is first mentioned by Ehrenberg, Abhandl. K. Akad. Wiss., **1841**, p. 369, but is neither described nor illustrated. It is first illustrated, I believe, in his Passat-Staub und Blut-Regen, Abhandl. K. Akad. Wiss. Berlin **1847**, and published separately in 1849, where it appears on *pl. 5, I, fig. 10*.

This variety was very frequent at Shohola Falls and at Angels. In both these cases it was found attached to stones in shallow swift water.

Monroe County: Popomoning Lake, 2045 *Hodge* (A-2166); Wier Lake, 2047 *Hodge* (A-2170). Pike County: Shohola Falls, 4 *Burke* (A-2192). Wayne County: Angels, 2026 *Burke and Patrick* (A-2134).

ACHNANTHES BORY

Cleve has divided this genus into several genera. Hustedt prefers to use Cleve's names to indicate subgenera or groups rather than to split the genus into several genera. Since Hustedt's arrangement is the one most generally used today, and until I have studied the genus more critically, I shall follow it. On this basis three groups are recognized in this study.

A. Transverse rows composed of very coarse punctae, the pseudoraphe usually excentric. See A′ and A″. ..... **Achnanthidium**

A′. Transverse rows composed of very fine punctae, the pseudoraphe central. **Microneis**

A″. Transverse rows composed of a double row of punctae..... **Achnanthes**

ACHNANTHES subgenus

Achnanthes coarctata (W. Sm.) Grun. *apud* Cl. and Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 20.

Achnanthidium coarctatum W. Sm., 1855, Ann. Mag. Nat. Hist. 2nd Ser. **15:** 8, *fig. 10.*

W. Smith cites Brebisson as the authority and gives as reference Kütz. Spec. Algarum, p. 54. This is not a correct reference and I cannot find that Brebisson ever published such a name.

The only habitat in which this species was found, was on the surfaces of dripping rocks which were outcrops of limestone.

Pike County: Shohola Falls, 15 *Burke* (A-2211), 9 *Burke* (A-2198).

MICRONEIS subgenus

A. Rapheless valve with a horseshoe-shaped area well-developed on one side of the middle of the valve. See A′ and A″.

B. Valve with raphe with the striae irregularly longer and shorter in the central area, more numerous on valve with raphe than on rapheless valve

C. Valve elliptic with attenuate rostrate ends ....**A. Peragalli**

C. Valve elliptic but ends usually rounded, not as above **A. Oestrupii** var.

B. Not as above, striae about the same number on both valves **A. lanceolata** and vars.

A′. Rapheless valve with striae broken so as to form a longitudinal line on each side of the pseudoraphe .....**A. Lewisiana**

A″. Rapheless valve without horseshoe-shaped area or longitudinal lines

D. Valve with raphe with a well-developed stauros reaching to the edges of the valve

E. Stauros on one side of raphe having an area which appears to be raised, thus giving the stauros on that side a bifurcate appearance **A. hungarica**

E. Stauros having the same appearance on both sides of the central nodule **A. exigua**

D. Valve with raphe with or without a stauros, if present not reaching to edges of valve, striae fine, over 20 in 10 μ

F. Valve linear ..... **A. linearis**

F. Valve with capitate-rostrate ends, striae usually slightly more distantly spaced at center of valve around central nodule **A. microcephala**

F. Hard to distinguish from the above, but ends usually rounded or somewhat rostrate, not capitate, striae not more distant at central nodule **A. minutissima**

Achnanthes exigua Grun. *apud* Cl. and Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 21.

This species was found only once and then it was rare.

Monroe County: Popomoning Lake, 2045 *Hodge* (A-2166).

Achnanthes hungarica Grun. *apud* Cl. and Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 20.

Achnanthidium hungaricum Grun., 1863, Verh. Zool. Bot. Ges. Wien, **13:** 146.

This species was only found once and then it was rare. It is characterized by the fact that the stauros appears to be bifurcate on one side of the central nodule, but close examination shows that this is not true.

Monroe County: Mountain Lake, 2051 *Hodge* (A-2178).

Achnanthes lanceolata (Bréb.) Grun. *apud* Cl. and Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 23.

Achnanthidium lanceolatum Bréb. *ex* Kützing, 1849, Spec. Algarum, p. 54.

This species was very frequent in the shallow water of a small tributary of Mill Creek, from the surface of leaves of a very small puddle near Mill Creek, enmeshed in moss in the swift water of Mill Creek, and in the surface scum on rocks in Raymondskill Falls.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131); Mountain Lake, 2051 *Hodge* (A-2178). Northampton County: Green Pond, 2050 *Hodge* (A-2177). Pike County: Shohola Falls, 3 *Burke* (A-2190), 15 *Burke* (A-2211), 5 *Burke* (A-2195). Wayne County: Angels, 2021–24 *Burke and Patrick* (A-2124–29).

Achnanthes lanceolata var. **apiculata** var. nov.

PLATE I, FIGS. 4, 5

Valvae elliptico-lanceolatae, 28 μ longae, 10–11 μ latae, apicibus apiculatis. Valva superior ad instar soleae equinae effigiem in medio ostendens, pseudoraphe anguste lanceolata; striis radiantibus, 10–12 in 10 μ. Valva inferior aream axialem angustam et aream centralem rotundatam exhibens; striis validis radiantibus, 10 in 10 μ. **Type:** Shohola Falls, 3 *Burke* (A-2190).

A noteworthy feature of this diatom is that the valve with a raphe has much more strongly radiate striae than the valve without a raphe. It dif-

fers from *A. lanceolata* v. *robusta* in that the ends are more apiculate than in *robusta* and the axial area is narrower and not granular.

This diatom was only found in one geographical habitat, Shohola Falls, but it was well distributed in the various ecological habitats here.

Pike County: Shohola Falls; 3 *Burke* (A-2190), 10–14 *Burke* (A-2201–10).

Achnanthes lanceolata v. **rostrata** Hust. *apud* Pascher, 1930, Süssw. Flora Mitteleurop., Heft 10: 208. *fig. 306b.*

In this study this variety was only found in running water. It was very frequent in the surface scum on rocks in little pools in Raymondskill Falls.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Shohola Falls, 10–11 *Burke* (A-2200–02); Lake Wallenpaupek tributary, 5 *Burke* (A-2195). Wayne County: Angels, 2026 *Burke and Patrick* (A-2134).

Achnanthes Lewisiana sp. nov.

PLATE I, FIGS. 2, 3

Valvae lineari-ellipticae, 15 μ longae, 4.6 μ latae. Valva superior pseudoraphem distinctam exhibens; striis 15–17 in 10 μ; utrimque per lineam longitudinalem interruptis. Valva inferior aream axialem ad valvae ipsae ¼–⅓ latitudinem prope nodulum centralem exhibens; area centrale nulla; striis parum radiantibus, 15–17 in 10 μ. **Type:** Shohola Falls, 14 *Burke* (A-2210).

This diatom is named in honor of Dean Ivey F. Lewis with whom I did my graduate work at the University of Virginia.

This species is particularly characterized by the interrupted striae on the rapheless valve. The most closely related fresh water species is *A. Suchlandti* Hustedt. The resemblance of my specimen to this species is mainly in the interrupted striae of the rapheless valve, for it differs from it in shape of axial area, number of striae, and size.

Both valves were seen and drawn from the same frustule.

Pike County: Greeley, 2 *Burke* (A-2188); Shohola Falls, 14 *Burke* (A-2208, 2210).

Achnanthes linearis (W. Sm.) Grun. *apud* Cl. and Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 23.

Achnanthidium lineare W. Sm., 1855, Ann. Mag. Nat. Hist. 2d ser. **15:** 8. *pl. 1, fig. 9.*

Though found in a great many habitats, this species was common or very frequent only in Davy's Run. It was found in association with moss, particularly *Fontinalis*, in running water.

Monroe County: Davy's Run, 2017 *Patrick* (A-2115), 2019 *Patrick* (A-2119), 2056 *Patrick* (A-2180); Pocono Lake Preserve, 2031 *Hodge* (A-2138), 2032 *Patrick* (A-2140), 2065 *Patrick* (A-2182). Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Pike County: Shohola Falls, 10–14 *Burke* (A-2200–09).

Achnanthes microcephala (Kütz.) Grun. *apud* Cl. and Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 22.

Achnanthidium microcephalum Kütz., 1844, Bacill., p. 75. *pl. 3, figs. 13, 19.*

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Trout Lake, 2049 *Hodge* (A-2174).

Achnanthes minutissima Kütz., 1844, Bacill., p. 75. *pl. 13, fig. 2c.*

This species was found only once and then it was rare.

Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195).

Achnanthes minutissima v. **cryptocephala** Grun. *apud* Van Heurck, 1880, Syn. Diat. Belgique, *pl. 27, figs. 41–44.*

Monroe County: Pocono Lake Preserve, Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42).

Achnanthes Oestrupii v. **parvula** var. nov.

PLATE I, FIGS. 6, 7

Valvae ellipticae apicibus parum rostratis, 12 μ longae, 6 μ latae. Valva superiot spatium hyalinum et in latere uno effigiem ad instar soleae equinae ostendens; striis parum radiantibus 15–16 in 10 μ. Valva inferior aream axialem angustam et aream centralem transversam exhibens; striis 28 in 10 μ, radiantibus, longis inaequaliter et ad nodulum centralem crassis. **Type:** Shohola Falls, 14 *Burke* (A-2209).

This variety differs from the species in that it is consistantly smaller in size. It also differs from the original description of the species in the number of striae of the rapheless valve. This species was first noted by Oestrup and considered a variety of *A. lanceolata.* A. Cleve (Acta Forst. Fenn. **22:** 53) first named it *A. lanceolata* v. *Oestrupii.* The illustrations of both authors indicate the striae number of the rapheless valve as 10–12 in 10 μ. Hustedt raised the variety to specific rank, and states the striae number of the rapheless valve is "10–14 (measuring on the edge of the short striae forms) or 14–18 (measuring on the pseudoraphe of the longer striated forms)." My specimens have striae 15 in 10 μ whether measured at margin or inner edge of striae.

Both valves were seen on the same frustule.

Pike County: Shohola Falls, 10, 14 *Burke* (A-2200, 2209).

Achnanthes Peragallii Brun and Herib. *apud* Herib., 1893, Diat. Auvergne, p. 50. *pl. 1, fig. 4.*

This species was rare in the two localities where it was found. In both cases it was in running water.

Pike County: Shohola Falls, 10 *Burke* (A-2200); Lake Wallenpaupek tributary, 5 *Burke* (A-2195).

ACHNANTHES subgenus

Achnanthes Stewartii sp. nov.

PLATE II, FIGS. 1–3

Valvae ellipticae, 16 μ longae, 7.5 μ latae, area axiali angusta, costis tenuibus 14 in 10 μ, serie duplici punctorum parvorum interpositu. **Type:** Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2194).

This species is named in honor of Dr. Thomas S. Stewart, Curator of the Microscopic Department of the Academy of Natural Sciences of Philadelphia, who has kindly made most of the photographs of diatoms which I have published.

It is with some hesitation that I put this species in this subgenus. The costae are not very pronounced, but the presence of a double row of punctae between each two costae places it here.

This species was only found in one locality, but as it is a very distinct species and of frequent occurrence I have described it.

Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2194–95).

AMPHIPLEURA KÜTZING

Amphipleura pellucida Kützing, 1844, Bacill., p. 103. *pl. 3, fig. 52.*

Frustulia pellucida Kütz., 1833, Linnaea, **1833:** 543. *pl. 13, fig. 11.*

This species seems to prefer circum-neutral waters. It was found only once in this study.

Luzerne County: Harvey Lake, 2043 *Hodge* (A-2162).

VANHEURCKIA BRÉBISSON

The name *Frustulia*, sometimes applied to this genus, is invalid according to the International Rules of Botanical Nomenclature.

Vanheurckia rhomboides (Ehr.) Bréb., 1869, Ann. Soc. Phy. Mic. Belge **1:** 204.

Navicula rhomboides Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 419. *pl. 3, fig. I, 15.*

This species was very frequent in Lost Lake which is a strongly distrophic lake which contains a great deal of *Sphagnum*. It is found only in acid water, and usually in association with moss.

Lackawanna County: Indian Lake, 2044 *Hodge* (A-2164). Monroe County: Lost Lake, 2020 *Turner* (A-2121); Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213); South Pocono Lake, 2010–11 *Patrick* (A-2101–03). Pike County: Shohola Falls, 11 *Burke* (A-2202).

Vanheurckia rhomboides v. **amphipleuroides** (Grunow)

Navicula rhomboides v. *amphipleuroides* Grun. *apud* Cl. and Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 47. *pl. 3, fig. 59.*

Grunow places this species in the group *Vanheurckia* under the genus *Navicula*.

This variety was found in shallow running water and was very frequent in a shallow tributary of Mill Creek. It was not found in the standing, strongly distrophic waters of some of the habitats studied.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Bushkill Creek, 1623 *Shulze* (A-2231); Lake Wallenpaupek tributary, 5 *Burke* (A-2195). Wayne County: Angels, 2021–22 *Burke and Patrick* (A-2124–25), 2026 *Burke and Patrick* (A-2134).

Vanheurckia rhomboides v. **crassinervia** (Bréb.) Van Heurck, 1881, Syn. Diat. Belgique, *pl. 17, figs. 4–5*, text (1885) p. 112.

Navicula crassinervia Bréb. *apud* W. Sm., 1853, Brit. Diat., **1:** 47.

Brébisson (Ann. Soc. Phy. Mic. Belge **1:**204) later transferred this species to the genus *Vanheurckia*.

This variety is the same as the invalidly published *Frustulia rhomboides* v. *saxonica* (Rabh.) De Toni.

This variety was well distributed in the more acid waters of this region and was of common occurrence in Davy's Run, Lost Lake, Pocono Lake, and Lake Tamaque.

Lackawanna County: Indian Lake, 2044 *Hodge* (A-2165). Monroe County: Davy's Run, 2013–15 *Patrick* (A-2107–11), 2018–19 *Patrick* (A-2117-19), 2056 *Patrick* (A-2180); Lost Lake, 2020 *Turner* (A-2121); Pocono Lake Preserve, Pocono Lake, 2034–38 *Patrick* (A-2144–52), 2065 *Patrick* (A-2182); Mud Run, 2031 *Hodge* (A-2138); South Pocono Lake, 2011–12 *Patrick* (A-2104–05); Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); Lake Tamaque, 2039–40 *Hodge* (A-2154–56). Pike County: 2188–90 *Shulze* (A-2234–36); Greeley, 2 *Burke* (A-2188); Shohola Falls, 4 *Burke* (A-2193), 10 *Burke* (A-2200), 12 *Burke* (A-2204), 14 *Burke* (A-2210).

Vanheurckia rhomboides v. **crassinervia** f. **capitata** comb. nov.

This form is the same as the invalidly published *Frustulia rhomboides* v. *saxonica* f. *capitata* (Mayer) Hustedt.

Valvae elliptico-lanceolatae, ca. 45 μ longae; apicibus rostrato-capitatis; striis subtilissimis, 34–36 in 10 μ.

This form is characterized by its capitate-rostrate ends. It is usually about 45 μ long.

This form was common in Pocono Lake from squeezings of *Eleocharis*, *Dicranum*, and *Hypnum* growing in one foot of water and was very frequent in scrapings of piles supporting the Emlen Dock in Pocono Lake. These two habitats were within fifty yards of each other.

Monroe County: Davy's Run, 2016 *Patrick* (A-2113); Mountain Lake, 2051 *Hodge* (A-2178); Pocono Lake Preserve, Pocono Lake, 2035–36 *Patrick* (A-2147–48), 2065 *Patrick* (A-2182); Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); South Pocono Lake, 2010 *Patrick* (A-2101). Pike County: Bushkill Creek, 1623 *Shulze* (A-2231); Shohola Falls, 3–4 *Burke* (A-2190–92), 11 *Burke* (A-2202), 14 *Burke* (A-2208).

Vanheurckia vulgaris (Thw.) Van Heurck, 1880, Syn. Diat. Belgique, *pl. 17, fig. 6*, text (1885) p. 112.

Colletonema vulgaris Thw., 1848, Ann. Mag. Nat. Hist. 2d ser. **1**, *pl. 12*.

This species was found in several localities but was rare in each case. It was usually found in running water.

Monroe County: Davy's Run, 2015 *Patrick* (A-2111); Wier Lake, 2047 *Hodge* (A-2171); Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: 2189 *Shulze* (A-2235); Shohola Falls, 4 *Burke* (A-2192), 14 *Burke* (A-2208). Wayne County: Angels, 2021 *Burke and Patrick* (A-2124), 2026 *Burke and Patrick* (A-2134).

CALONEIS CLEVE

Caloneis Lewisii sp. nov.

PLATE II, FIG. 4

Valvae bis constrictae longae 27 μ ad medium 8.7 μ apicibus cuneatae; striis transversis 19-20 in 10 μ; area axiali angusto, nodulo centrali majusculo subquadrangularis signis lunatis duobus crasso. **Type:** Illinois, Du Page County, 2423 *F. Drouet, P. C. Standley and J. A. Steyermark* (A-2018).

It is regrettable that the often used name, *Caloneis trinodis*, cannot be retained for this species. *Caloneis trinodis* is based upon the specimens of Lewis. Lewis misidentified his specimens as *Navicula trinodis* W. Sm. I have conferred with Dr. E. D. Merrill and Dr. Francis W. Pennell about using the name *Caloneis trinodis*, but they assure me that since this species is based upon the misidentification of Lewis, this cannot be done. In 1878 Grunow, apparently unaware of Lewis' specimens, called this species *Navicula Trochus* var.? *biconstricta*. Unfortunately the name *biconstricta* is preoccupied in the genus *Caloneis*. Thus it seems that the best thing to do is to name the species after Lewis who found the first specimens. I do not believe it correct to consider it a variety of *Caloneis Schumanniana* as Cleve (K. Sv. Vet. Akad. Handl. **26** (2): 53) and Reichelt (Archiv Hydrobiol. Planktonk. **1:** 231–32) have done.

In my recent paper (Proc. Acad. Nat. Sci. **95:** 71) I have given Boyer the credit for the name *Caloneis trinodis*. This was a mistake as Meister first made the combination in 1912. However, as shown above, this name is invalid.

Northampton County: Green Pond, 2050 *Hodge* (A-2176).

Caloneis silicula v. **alpina** Cl., 1893, K. Sv. Vet. Akad. Handl. **26** (2): 51.

It is very interesting to find this variety in the Pocono Plateau. The identification of the variety has been checked with Cleve and Möller type no. 273. Hustedt stated that this variety is only found in the high mountains of Europe.

In this study, the diatom was found only once, and then it was rare. From this I would infer that Davy's Run is not the ideal habitat, and the specimens which I found might be contaminations brought in by birds, etc. from some other habitat.

Monroe County: Davy's Run, 2014 *Patrick* (A-2110).

NEIDIUM PFITZER

A. Striae more than 20 in 10 μ
  B. Ends of valve rounded, not at all constricted
    C. Sides of valve parallel .....**N. bisulcata**
    C. Sides of valve undulate .....**N. bisulcata v. undulata**
  B. Ends of valve more or less constricted, from slightly rostrate to protracted rostrate ends
    D. Ends of valve only slightly constricted **N. affine**
    D. Ends of valve distinctly protracted and rostrate **N. affine v. amphirhynchus**

A. Striae less than 20 in 10 μ
  E. Valves linear
    F. Ends rounded .....**N. iridis f. vernalis**
    F. Ends wedge shaped .....**N. iridis v. amphigomphus**
  E. Valves linear-lanceolate
    G. Ends rounded .....**N. iridis**
    G. Ends subrostrate .....**N. iridis v. ampliata**

Neidium affine (Ehr.) Cl., 1894, K. Sv. Vet. Akad. Handl. **26** (2): 69.

Navicula affinis Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 417. *pl. 2, fig. II, 7.*

This species was rare in the two localities. In both cases it occurred in running water.

Monroe County: Davy's Run, 2013 *Patrick* (A-2107), 2019 *Patrick* (A-2119). Pike County: 1621 *Shulze* (A-2227).

Neidium affine v. **amphirhynchus** (Ehr.) Cl., 1894, K. Sv. Vet. Akad. Handl. **26** (2): 68.

Navicula amphirhynchus Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 417. *pl. 3, fig. I, 10.*

This variety was rare in two habitats.

Monroe County: Davy's Run, 2014 *Patrick* (A-2110). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

Neidium bisulcatum (Lagst.) Cl., 1894, K. Sv. Vet. Akad. Handl. **26** (2): 68.

Navicula bisulcata Lagst., 1873, Bihang K. Sv. Vet. Akad. Handl. **1** (14): 31. *pl. 1, fig. 8.*

This species was rare in the two localities where it was collected.

Pike County: 127 *Shulze* (A-2215), 2188 *Shulze* (A-2234).

Neidium bisulcatum v. **undulatum** O. Müll., 1898, Forschungsber. Biol. Stat. Plön **6:** 62–63.

This variety was rare in occurrence.

Pike County: Greeley, 2 *Burke* (A-2188).

Neidium iridis (Ehr.) Cl., 1894, K. Sv. Vet. Akad. Handl. **26** (2): 69.

Navicula iridis Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 418. *pl. 4, figs. 1, 2.*

Though found in several localities, it was of frequent occurrence in none.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County:

Davy's Run, 2014 *Patrick* (A-2109), 2019 *Patrick* (A-2119); Raymondskill Falls, 2025 *Patrick* (A-2131); Wier Lake, 2046 *Hodge* (A-2169). Northampton County: Green Pond, 2050 *Hodge* (A-2177). Pike County: 2188–90 *Shulze* (A-2234–36), 128–29 *Shulze* (A-2217–19); Greeley, 1 *Burke* (A-2184); Shohola Falls, 4 *Burke* (A-2192), 12 *Burke* (A-2204).

Neidium iridis v. **amphigomphus** (Ehr.) Mayer, 1917, Denks. K. Bayer. Bot. Ges. **13:** n. s. **7:** 30.

Navicula amphigomphus Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 417. *pl. 3, fig. I, 8.*

This variety was frequent in a locality simply designated by Shulze as Pike County.

Monroe County: Jaggie's Bog, 262 *Shulze* (A-2223). Pike County: 130 *Shulze* (A-2221).

Neidium iridis v. **ampliatum** (Ehr.) Cl., 1894, K. Sv. Vet. Akad. Handl. **26** (2): 69.

Navicula ampliata Ehr., 1842, Ber. K. Akad. Wiss. Berlin, **1842:** 337.

These specimens differ from the typical forms of this variety in that the sides of the valve are parallel and not convex.

Pike County: 2190 *Shulze* (A-2236).

Neidium iridis v. **vernale** Reichelt, 1897, Sitzungsber. Naturforsch. Ges. Leipsig **24:** 8–9.

This variety was only found once and then it was rare.

Pike County: 128 *Shulze* (A-2217).

DIPLONEIS EHRENBERG

This genus was rarely encountered in this study. The two species listed below were only found twice and then they were rare.

Diploneis ovalis (Hilse) Cl., 1891, Acta Soc. pro Fauna et Flora Fennica **8** (2): 44. *pl. 2, fig. 13.*

Pinnularia ovalis Hilse *in* Rabenhorst, 1861, Algen Europa, no. 1025.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131).

Diploneis Smithii (Bréb. *ex* W. Sm.) Cl., 1894, K. Sv. Vet. Akad. Handl. **26** (2): 96.

Navicula Smithii Bréb. *ex* W. Sm., 1856, Brit. Diat. **2:** 92.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131).

STAURONEIS EHRENBERG

A. Ends of valve with septum, valves slightly biconstricted .....**S. Smithii**

A. Ends of valve without septum

B. Raphe broad, striae usually less than 20 in 10 μ .....**S. phoenicenteron**

B. Raphe linear, striae 20 or more in 10 μ .....**S. anceps** and vars.

B. Raphe linear, striae about 30 in 10 μ, small forms usually less than 25 μ long **S. Kriegeri**

Stauroneis anceps Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 306, 422. *pl. 2, fig. I, 18.*

This species was found in several localities but was frequent in none.

Lackawanna County: Indian Lake, 2044 *Hodge* (A-2165). Monroe County: Davy's Run, 2014–15 *Patrick* (A-2110–11), 2018–19 *Patrick* (A-2118–19); Mountain Lake, 2048 *Hodge* (A-2172); Pocono Lake Preserve, South Pocono Lake, 2010 *Patrick* (A-2102); Trout Lake, 2049 *Hodge* (A-2174); Wier Lake, 2046–47 *Hodge* (A-2169–70). Pike County: 2188 *Shulze* (A-2234), 128–30 *Shulze* (A-2217–21); Shohola Falls, 12 *Burke* (A-2204).

Stauroneis anceps v. **amphicephala** (Kütz.) Cl., 1894, K. Sv. Vet. Akad. Handl. **26** (2): 148.

Stauroneis amphicephala Kütz., 1844, Bacill. p. 105. *pl. 30, fig. 25.*

This variety is characterized by having the striae easily resolved into punctae. It was only found in one locality and then it was rare.

Pike County: 127 *Shulze* (A-2215).

Stauroneis anceps v. **gracilis** (Ehr.) Brun, 1880, Diat. Alpes et Jura et Région Suisse et Française des Environs de Genève, p. 89. *pl. 9, fig. 2.*

Stauroneis gracilis Ehr., 1843, Abhandl. K. Wiss. Berlin **1841:** 423. *pl. 1, fig. II, 14.*

This variety though found in several localities was frequent in none.

Monroe County: Davy's Run, 2015 *Patrick* (A-2111); Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138); Pocono Lake, 2036 *Patrick* (A-2148). Wayne County: Angels, 2022 *Burke and Patrick* (A-2125).

Stauroneis anceps v. **linearis** (Ehr.) Van Heurck, 1880, Syn. Diat. Belgique, p. 69. *pl. 4, figs. 7, 8.*

Stauroneis linearis Ehr., 1843, Abhandl. K. Wiss. Berlin **1841:** 423. *pl. 1, fig. II, 11.*

This variety was found only in one locality and then it was rare.

Monroe County: Pocono Lake Preserve, Pocono Lake, 2036 *Patrick* (A-2148).

Stauroneis Kriegeri nomen nova

Valvae lineares 21 μ longae, 4 μ latae, apicibus constrictis capito-rostratis; striis radiantibus, 26 in 10 μ, area axiali angusta; stauro lineari.

This species was first observed by Krieger, who named it *Stauroneis pygmaea* (Beiträge zur Naturdenkmalpflege **13:** 272. *pl. 2, fig. 28* (1929)). However, this name is preoccupied by a species described by Castracana in 1886 (Voyage of H.M.S. Challenger, Botany **2:** 25. *pl. 29, fig. 7*).

As Krieger points out, this species may vary between 20–23 μ in length and 4–5 μ in breadth. He states the striae are 30 in 10 μ, but in my specimens they are 26 in 10 μ. The stauros may appear broader on one side of the central nodule than on the other.

This species is named in honor of Mr. Krieger.

Monroe County: Davy's Run, 2017 *Patrick* (A-2115). Wayne County: Angels, 2023 *Burke and Patrick* (A-2127).

Stauroneis phoenicenteron (Nitzsch.) Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** *pl. 2, fig. V, 1.*

Bacillaria phoenicenteron Nitzsch. 1817, N. Schrift. Naturf. Ges. Halle **3:** 92.

This species was common in the squeezings from surface vegetation in shallow water of Wier Lake where the pH of the water was 6.6. It is also common in some collections by Shulze from Pike County.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Jaggie's Bog, 262–63 *Shulze* (A-2223–25); Pocono Lake Preserve, South Pocono Lake, 2010 *Patrick* (A-2101); Raymondskill Falls, 2025 *Patrick* (A-2131); Wier Lake, 2046 *Hodge* (A-2168). Northampton County: Green Pond, 2050 *Hodge* (A-2176). Pike County: 127–29 *Shulze* (A-2215–19), 2190 *Shulze* (A-2236); Bushkill Creek, 1621 *Shulze* (A-2227). Wayne County: Angels, 2021 *Burke and Patrick* (A-2124).

Stauroneis Smithii Grun., 1860, Verh. Zool. Bot. Ges. Wien **10:** 464. *pl. 4* (Grunow's *pl. 6*), *fig. 16.*

This species, occurring only in flowing water, was rare in the localities given below.

Monroe County: Davy's Run, 2018 *Patrick* (A-2117); Pike County: Shohola Falls, 3–4 *Burke* (A-2190–92), 11 *Burke* (A-2202).

NAVICULA

A. Punctae of striae forming longitudinal and transverse rows perpendicular to each other ..... **Naviculae Orthostichae**

A. Punctae of striae forming decussating rows ..... **Naviculae Decussatae**

A. Punctae of striae not as above

B. Striae transversely lineate ..... **Naviculae Lineolatae**

B. Striae not transversely lineate

C. Raphe enclosed in silicious rib, terminal nodule thickened **Naviculae Bacillares**

C. Raphe not enclosed

D. Central pores somewhat distant, axial area narrow or uniting with central area to form a lanceolate space **Naviculae Entoleiae**

D. Central pores not distant

E. Central area not distinct — small forms less than 20 μ **Naviculae Minusculae**

E. Central area variously formed

F. Striae radiate throughout

G. Striae clearly alternately long and short at central area, valves more or less elliptic in shape ..... **Naviculae Heterostichae**

G. Striae may be uneven but not definitely longer and shorter at central area — central area quadrate or forming a transverse fascia **Naviculae Mesoleiae**

F. Striae not radiate throughout, median striae distinctly more distant from each other than those in other parts of the valve **Naviculae Decipientes**

NAVICULAE ORTHOSTICHAE Cleve

Valves usually elongate, lanceolate to linear. The median line with small or elongate central nodule, and with small or indistinct terminal fissures.

Navicula cuspidata Kütz., 1844, Bacill., p. 94. *pl. 3, fig. 24.*

Frustulia cuspidata Kütz., 1833, Linnaea **8:** 549. *pl. 14, fig. 26.*

This species was present only in one locality.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2161).

NAVICULAE DECUSSATAE Cleve

Valves elliptical with attenuate rostrate ends. The punctae of the striae are arranged in obliquely decussating rows. There is only one species in this region.

Navicula placenta Ehr., 1854, Mikrogeologie, p. 33. *pl. 12, fig. 23.*

This species, though found in several habitats, was very frequent in only one, where it occurred on a wall dripping with water to the side of Shohola Falls.

Pike County: 2188–89 *Shulze* (A-2234–35); Bushkill Creek, 1623 *Shulze* (A-2231); Greeley, 1 *Burke* (A-2184), 2 *Burke* (A-2188); Shohola Falls, 14 *Burke* (A-2208–10). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

NAVICULAE LINEOLATAE Cleve

A. Terminal striae parallel or convergent
  B. Striae usually 15 or more in 10 μ; valves usually less than 50 μ long
    C. Linear or slightly lanceolate with rounded ends, the median stria on each side of the central nodule often decidedly longer than the other striae about the central nodule .....**N. cincta** and var.
    C. Central area more or less rounded
      D. Valve rhombic lanceolate .....**N. cryptocephala v. pumila**
      D. Valve lanceolate with attenuate, rostrate ends **N. cryptocephala**
      D. Valve lanceolate with acute ends **N. radiosa v. tenella**
  B. Striae less than 15 in 10 μ
    E. Valves 30 μ or less in length
      F. Valves with strongly capitate ends, striae 8–10 in 10 μ **N. hungarica v. capitata**
      F. Valves with slightly rostrate ends, striae 14 in 10 μ **N. cryptocephala v. veneta**
    E. Valves longer than 30 μ
      G. Terminal nodule of valve expanded to produce a hyaline space **N. globulifera**
      G. Terminal nodule not so expanded

H. Ends of valve variously produced

I. Ends of valve attenuate-rostrate and slightly capitate; valve lanceolate
N. rhynchocephala

I. Ends of valve cuneate; valve linear
N. viridula v. linearis

H. Ends of valve not produced; valve lanceolate
N. radiosa

A. Terminal striae radiate throughout

J. Striae at central area equally shortened

K. Central area more or less rounded

L. Valve lanceolate, striae at central area more distantly spaced
N. lanceolata

L. Valve ovate lanceolate with attenuate, rostrate ends
N. anglica

K. Central area transverse, central striae not more distantly spaced
N. dicephala

J. Striae at central area irregular in length

M. Striae at central area alternately longer and shorter and distinctly more distantly spaced than in the rest of the valve
N. quadripartita

M. Striae not distinctly more distantly spaced about the central area

N. Striae 16–18 in 10 μ; valve elliptical-lanceolate with distinctly attenuate rostrate ends .....**N. decussis**

N. Striae coarser; valve ovate-lanceolate, ends distinctly attenuate rostrate .....**N. exigua v. capitata** n. var.

Navicula anglica Ralfs *apud* Pritchard, 1861, Syst. Hist. of the Infusoria, p. 900.

This species was rare in two collections.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: 127 *Shulze* (A-2215).

Navicula cincta (Ehr.) Ralfs *apud* Pritchard, 1861, Syst. Hist. of the Infusoria, p. 901.
Pinnularia cincta Ehrenberg, 1854, Mikrogeologie, *pl. 10, fig. II, 6.*

For further discussion concerning the authorities for this name see Proc. Acad. Nat. Sci. Phila. **95:** 72.

This species was found only in one habitat and then it was rare.

Monroe County: Popomoning Lake, 2045 *Hodge* (A-2166).

Navicula cincta v. **angusta** (Grun.) Cl., 1893, K. Sv. Vet. Akad. Handl. **27** (3): 17.
Navicula angusta Grun., 1860, Verh. Bot. Zool. Ges. Wien **10:** 528. *pl. 3, fig. 19.*

This variety was rare in both localities. The specimens in Tobyhanna Creek were shorter than usual, being only 40 μ long.

Monroe County: Pocono Lake Preserve, Tobyhanna Creek, 2033 *Patrick* (A-2142). Pike County: Shohola Falls, 14 *Burke* (A-2210).

Navicula cryptocephala Kütz., 1844, Bacill., p. 95. *pl. 3, fig. 26.*

Monroe County: Trout Lake, 2049 *Hodge* (A-2175); Wier Lake, 2047 *Hodge* (A-2170); Raymondskill Falls, 2025 *Patrick* (A-2131). Northamp-

ton County: Green Pond, 2050 *Hodge* (A-2176). Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195); Shohola Falls, 3 *Burke* (A-2190), 4 *Burke* (A-2192). Wayne County: Angels, 2022 *Burke and Patrick* (A-2125), 2026 *Burke and Patrick* (A-2134).

Navicula cryptocephala v. **pumila** Grun. *apud* Van Heurck, 1880, Syn. Diat. Belgique, *pl. 8, fig. 6, 7.*

Grunow suggests this is a variety but questions it. However, later writers such as Cleve and Hustedt have given him credit for this combination.

Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2095). Wayne County: Angels, 2026 *Burke and Patrick* (A-2134).

Navicula cryptocephala v. **veneta** (Kütz.) Rabh., 1864, Flora Europaea Algarum, p. 198.

Navicula veneta Kütz., 1844, Bacill., p. 95. *pl. 30, fig. 76.*

This variety was rare in the one locality.

Northampton County: Green Pond, 2050 *Hodge* (A-2176).

Navicula dicephala Ehr., 1838, Die Infusionsthierchen als volkommene Organismen, p. 185.

This species was rare in the various localities in which it was encountered.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: 2188 *Shulze* (A-2234); Bushkill Creek, 1623 *Shulze* (A-2231); Shohola Falls, 12 *Burke* (A-2205).

Navicula decussis Oestrup, 1910, Danske Diat., p. 77. *pl. 2, fig. 50.*

My specimens are as Oestrup's illustration except that the striae appear to be somewhat curved. Hustedt in A. Schmidt's Atlas Diatomaceen-Kunde, *pl. 398, figs. 36, 37,* illustrates a diatom with curved striae and a punctum in the central nodule which he assigns to this species.

I cannot be sure, from the descriptions and original illustrations, of the difference between *N. decussis* and *N. Thingvallae.* I have not seen the types so will not try to make any critical evaluation of the two species.

This species was not of frequent occurrence in any of the habitats.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123–24).

Navicula exigua v. **capitata** var. nov.

Valvae elliptico-lanceolatae, apicibus rostrato-capitatis, 29 μ longae, 10 μ latae; striis 14–15 in 10 μ, radiantibus, ad nodulum centralem longis inaequaliter; area axiali angusta; area centrali transversa. **Type:** Shohola Falls, 10 *Burke* (A-2200).

The specimens vary in length from 22–30 μ, in breadth from 10–11 μ. Hustedt has illustrated in A. Schmidt's Atlas der Diatomaceen-Kunde, *pl. 398, figs. 24–26,* specimens which seem to be the same as mine. He has placed them under the species name. However, if one examines the original figure and description of Gregory, it is clear that Hustedt's specimens are not the same as the type. Gregory (Quart. Jour. Micros. Sci. **2:** 98–99.

pl. 4, fig. 14) states, "its form is broadly elliptical with acute but not produced apices — the striae are distinct and radiate."

Grunow in Van Heurck's Synopsis des Diatomées Belgique (*pl. 8, fig. 32*) and in Cleve and Moeller Type Slide no. 261 indicates that this species has a transverse central area formed by the irregular shortening of the central striae. Otherwise his specimens are as Gregory's illustration. The question as to whether Grunow's and Gregory's specimens are the same will have to await the study of type or isotype material since Gregory makes no statement concerning the central area.

Pike County: 2188 *Shulze* (A-2234); Lake Wallenpaupek tributary, 5 *Burke* (A-2195); Shohola Falls, 10–11 *Burke* (A-2200–02), 14 *Burke* (A-2210).

Navicula globulifera Hustedt, 1927, Archiv für Hydrobiol. **18:** 164. *pl. 5, fig. 7.*

I believe this is the first record of this species in North America. My specimens are 37–39 μ long, 5.8–7 μ broad, and the striae are 12 in 10 μ.

Monroe County: Trout Lake, 2049 *Hodge* (A-2175). Pike County: Greeley, 2 *Burke* (A-2188); Lake Wallenpaupek tributary, 5 *Burke* (A-2195). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

Navicula hungarica v. **capitata** (Ehr.) Cl., 1895, K. Sv. Vet. Akad. Handl. **27** (3): 16.
Pinnularia capitata Ehr., 1854, Mikrogeologie, *pl. 37, fig. III, 9.*

In 1848, Ehrenberg (Ber. K. Akad. Wiss. Berlin **1848:** 18) just mentions this species. In 1838 Ehrenberg (Infusionsthierchen als volkommene Organismen, p. 185, *pl. 13, fig. 20*) describes a *Navicula capitata* which is quite different from the species in question.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Shohola Falls, 4 *Burke* (A-2192).

Navicula lanceolata (Ag.) Kütz., 1844, Bacill., p. 94. *pl. 30, fig. 48; pl. 28, fig. 38.*
Frustulia lanceolata Ag., 1827, Flora (Bot. Zeitung) **10:** 626.

Northampton County: Green Pond, 2050 *Hodge* (A-2177).

Navicula quadripartita Hustedt, 1937, Archiv für Hydrobiol. und Planktonk. Suppl. **15:** 263.

This species is first published by Hustedt in 1934 in A. Schmidt's Atlas Diatomaceen-Kunde, *pl. 400, figs. 12–15.* According to the International Rules of Botanical Nomenclature this is not a valid publication so the above later record is given.

Hustedt states that this species is usually associated with moss.

Pike County: Bushkill Creek, 1623 *Shulze* (A-2231); Greeley, 2 *Burke* (A-2188); Lake Wallenpaupek tributary, 5 *Burke* (A-2195).

Navicula radiosa Kütz., 1844, Bacill., p. 91. *pl. 4, fig. 23.*

This species was very frequent from the squeezings of the surface vegetation of Mountain Lake.

Luzerne County: Harvey Lake, 2042–43 *Hodge* (A-2160–62). Monroe

County: Mountain Lake, 2051 *Hodge* (A-2178); Popomoning Lake, 2045 *Hodge* (A-2166). Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195); Shohola Falls, 10–11 *Burke* (A-2200–02).

Navicula radiosa v. **tenella** (Bréb.) Cl., 1895, K. Sv. Vet. Akad. Handl. **27** (3): 17.

Navicula tenella Bréb. *ex* Kütz., 1849, Spec. Algarum, p. 74.

This species was of very frequent occurrence in certain habitats of Pocono Lake, Trout Lake, and Shohola Falls. It seems to prefer shallow water and is associated with algae or moss.

Luzerne County: Harvey Lake, 2042–43 *Hodge* (A-2160–62). Monroe County: Davy's Run, 2015 *Patrick* (A-2111), 2019 *Patrick* (A-2119); Mountain Lake, 2051 *Hodge* (A-2178); Pocono Lake Preserve, Pocono Lake, 2035–36 *Patrick* (A-2146–48), 2065 *Patrick* (A-2182); Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); South Pocono Lake, 2010 *Patrick* (A-2101); Trout Lake, 2049 *Hodge* (A-2174). Pike County: Greeley, 1 *Burke* (A-2184); Shohola Falls, 3–4 *Burke* (A-2190–92), 10–11 *Burke* (A-2200–02), 13 *Burke* (A-2206). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

Navicula rhynchocephala Kütz., 1844, Bacill., *pl. 30, fig. 35.*

This species, though found in several localities was rare in all.

Luzerne County: Harvey Lake, 2042–43 *Hodge* (A-2160–62). Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195); Shohola Falls, 10 *Burke* (A-2201). Wayne County: Angels, 2026 *Burke and Patrick* (A-2134).

Navicula viridula v. **linearis** Hustedt

This variety was first published in 1936 in A. Schmidt's Atlas Diatomaceen-Kunde *pl. 405, figs. 13, 14.* No description was present. Later, 1937, Archiv für Hydrobiologie, Supplement **15:** 264 a description in German was given. To date no Latin description has been furnished so I am including one in order to validate the name.

Valvae lineares, 65–100 μ longae, 12 μ latae, apicibus cuneatis; striis 8–9 in 10 μ, intermediis radiantibus, terminalibus convergentibus, distincte transverse lineatis.

This species though rare in several localities was frequent in none.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Shohola Falls, 10 *Burke* (A-2201). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123), 2026 *Burke and Patrick* (A-2134).

NAVICULAE BACILLARES Cleve

Navicula americana Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 417.

At Shohola Falls a form only 38 μ long and 7 μ broad was found. In no case was this diatom of frequent occurrence.

Pike County: 127 *Shulze* (A-2215), 130 *Shulze* (A-2221); Shohola Falls, 10 *Burke* (A-2201).

Navicula bacillum Ehr., 1839, Abhandl. K. Akad. Wiss. Berlin **1838:** 130.

This species was found in only two localities and was frequent in neither.

Luzerne County: Harvey Lake, 2043 *Hodge* (A-2162). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

NAVICULAE ENTOLEIAE Cleve

A. Frustules in filaments
  B. Valves lanceolate, striae marginal ..... **N. Keeleyi**
  B. Valve concave, striae not marginal..... **N. contenta v. biceps**
A. Frustules not in filaments.
  C. Valves concave, length of valve 20 μ or more, ends narrowed, rostrate **N. concava**
  C. Valves not concave
    D. Striae more than 20 in 10 μ
      E. Valves swollen at center, about 15 μ long . **N. perpusilla**
      E. Valves linear-lanceolate, not swollen at center of valve over 20 μ long ..... **N. poconoensis**
    D. Striae less than 20 in 10 μ, ends of valve distinctly capitate **N. hassiaca**

Navicula concava sp. nov.

PLATE II, FIG. 6

Valvae utrimque concavae, 21.7 μ longae, 5 μ ad nodulum centralem latae; apicibus rostratis, area axiali late lanceolata; area centrali inaequali; striis 27–28 in 10 μ, prope medium radiantibus in apicibus parallelis. **Type:** Pike County; Greeley, squeezings from *Sphagnum* in swamp, 2 *Burke* (A-2188).

This diatom is typical of the members of the Entoleiae except the striae are parallel or only very slightly radiate at the ends. Cleve in describing the group states that the striae are radiate at the ends. However, as the species fits this group in all other respects, I think it well to include it until a more thorough study is made.

This species occurred in only one locality, but was of frequent occurrence.

Pike County: Greeley, 2 *Burke* (A-2188–89).

Navicula contenta v. **biceps** (Arnott) Van Heurck, 1885, Syn. Diat. Belgique, p. 109.

Diadesmis biceps Arn. *ex* Cl. and Möll. no. 175. The determinations of these specimens were made by Grunow.

This variety is rare in the two localities.

Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195); Shohola Falls, 9 *Burke* (A-2198), 14 *Burke* (A-2208).

Navicula hassiaca Krasske, 1925, Abhandl. u. Ber. Ver. für Naturk. **56:** 47. *pl. 2, fig. 26.*

Pike County: Greeley, 1 *Burke* (A-2184); Lake Wallenpaupek tributary, 14 *Burke* (A-2210).

Navicula Keeleyi sp. nov.

PLATE II, FIG. 7

Valvae lanceolatae 19–30 μ longae, 4–5 μ latae, in fibris; apicibus capitato-rostratis, area axiali et area centrali late lanceolata; striis marginibus, 30 in 10 μ. **Type:** Pike County, Shohola Falls, scrapings from dripping rock face, side wall of gorge, above concrete bridge crossing road below falls, 7 *Burke* (A-2197).

This species is named in honor of Mr. Frank J. Keeley who first called my attention to this diatom. He found it in wet moss at Flat Rock, Montgomery County, Pennsylvania. Mr. Keeley has also helped me in describing the species.

This species is very common in these collections. Its manner of growth in filaments immediately calls it to one's attention. It is distinguished from the other filamentous forms of this group by its broad axial and central areas which form a lanceolate space.

Pike County: Shohola Falls, 7 *Burke* (A-2196–97), 9 *Burke* (A-2198–99).

Navicula perpusilla Grun., 1860, Verh. Zool. Bot. Ges. Wien **10:** 552. *pl. 4* (Grunow *pl. 2*), *fig. 7*.

Hustedt states that this species is found especially in mountainous regions. This species was very frequent on a dripping rock face at Shohola Falls.

Pike County: Shohola Falls, 7 *Burke* (A-2196), 9 *Burke* (A-2198).

Navicula poconoensis sp. nov.

PLATE II, FIG. 5

Valvae linearis-lanceolatae 26.4 μ longae, 4.6 μ latae, apicibus late rostratis; area axiali lanceolata, area centrali rotundata; striis 31 in 10 μ, in apicibus parallelis. **Type:** Pike County, Greeley, squeezings from *Sphagnum* in swamp, 2 *Burke* (A-2188).

This species, as *N. concava*, differs from other members of the Entoleiae in that the terminal striae are parallel instead of radiate, but it agrees in all other respects with members of this group.

The species is most closely related to *N. Flotowii* but differs from it in the size of the valve, the shape of the apices, and the fact that it does not form filaments.

Pike County: Greeley, 2 *Burke* (A-2188–89).

NAVICULAE MINUSCULAE Cleve

A. Valve elliptical in outline, striae about 30 in 10 μ
   B. Striae parallel or slightly radiate ..... **N. muralis**
   B. Striae strongly radiate ..... **N. atomus**
A. Valve linear-elliptic with rostrate ends, striae about 30 in 10 μ. As seen through the microscope the striae at margin of valve are on a different level of focus than at raphe ..... **N. festiva**

Navicula atomus (Kütz.) Grun., 1860, Verh. Zool. Bot. Ges. Wien **10:** 552. *pl. 2, fig. 6.*
Amphora atomus Kütz., 1844, Bacill., p. 108. *pl. 30, fig. 70.*

This species was only found in one locality.
Pike County: Shohola Falls, 11 *Burke* (A-2202).

Navicula festiva Krasske, 1925, Abhandl. u. Bericht. Ver. für Naturk. Cassel **56:** 47. *pl. 1, fig. 16.*

The name *Navicula vitrea* (Oestrup) Hustedt cannot be applied to this species as it is preoccupied by *N. vitrea* Cleve, 1893, (K. Sv. Vet. Akad. Handl. **26** (2): 111).

This species was of very frequent occurrence at Greeley, where it was found in association with *Sphagnum*.

Pike County: Greeley, 2 *Burke* (A-2188).

Navicula muralis Grun. *apud* Van Heurck, 1880, Syn. Diat. Belgique, *pl. 14, fig. 27.*

This species was rare in the one locality.
Monroe County: Trout Lake, 2049 *Hodge* (A-2174).

NAVICULAE HETEROSTICHAE Cleve

A. Valve elliptical in shape, central area large and rounded. . . .**N. scutiformis**
A. Valve lanceolate to rhombic-elliptical, central area indistinct . **N. cocconeiformis**
A. Valve orbicular, central area indistinct, less than 20 μ long. .**N. pseudoscutiformis**

Navicula cocconeiformis Greg., 1856, Quart. Jour. Micros. Sci. **4:** 6. *pl. 1, fig. 22.*

This species was only found in running water, but it was not of frequent occurrence in any habitat wherein it was found.

Monroe County: Davy's Run, 2014 *Patrick* (A-2110), 2016–18 *Patrick* (A-2113–18), 2056 *Patrick* (A-2180); Pocono Lake Preserve, Tobyhanna Creek, 2033 *Patrick* (A-2142). Pike County: Shohola Falls, 10–11 *Burke* (A-2201–02), 13 *Burke* (A-2206).

Navicula pseudoscutiformis Hustedt *apud* Pascher, 1930, Die Süssw. Flora Mitteleurop., Heft 10: 291. *fig. 495.*

This species was rare in the localities where it was found.

Monroe County: Davy's Run, 2019 *Patrick* (A-2119); Wier Lake, 2047 *Hodge* (A-2170). Pike County: Shohola Falls, 11 *Burke* (A-2202), 14 *Burke* (A-2210).

Navicula scutiformis Grun., 1881, in A. Schmidt's Atlas Diat., *pl. 70, fig. 62.*

This species was found in only one locality.
Monroe County: Davy's Run, 2019 *Patrick* (A-2119).

NAVICULAE MESOLEIAE Cleve

The valve is symmetrical, linear to elliptical with usually obtuse or rostrate ends. The axial area is narrow or indistinct. The central area is

large, quadrate or a transverse fascia. The striae are fine, punctate and radiate throughout. The connecting zone is not complex.

A. Valves with isolated stigma in the central area; valve often somewhat lanceolate in shape and may have rostrate capitate ends.....**N. mutica**

A. Valves without an isolated stigma in the central area, ends of valve broadly rounded.

B. Terminal nodules laterally expanded to form a clear area . **N. pupula** and vars.

B. Terminal nodules not so expanded

C. Terminal striae radiate and curved.....**N. bacilliformis**

C. Terminal striae not so formed

D. Median striae at the central area approximately the same length so that the central area appears clear-cut but small **N. minima** var.

D. Median striae of central area very irregular in length

E. Very small forms, almost orbicular in shape **N. subatomoides**

E. Valves over 12 μ long, elliptical in shape

F. Central area broad, somewhat rhomboidal in shape **N. variostriata**

F. Central area narrowly rectangular in shape **N. Rotaeana**

Navicula bacilliformis Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 44. *pl. 2, fig. 51.*

This species was rare in the two localities cited below.

Monroe County: Popomoning Lake, 2045 *Hodge* (A-2166); Wier Lake, 2047 *Hodge* (A-2170).

Navicula minima v. **atomoides** (Grun.) Cl., 1894, K. Sv. Vet. Akad. Handl. **26** (2): 128.

Navicula atomoides Grun. *apud* Van Heurck, 1880, Syn. Diat. Belgique *pl. 14, fig. 12*, text (1885) p. 107. Van Heurck Type Slide no. 219.

This species was very frequent in the bottom vegetation in shallow water in Wier Lake and Davy's Run and in scrapings from rocks at Shohola Falls.

Monroe County: Davy's Run, 2016–17 *Patrick* (A-2113–15); Pocono Lake Preserve, Tobyhanna Creek, 2032 *Patrick* (A-2140); Pocono Lake, 2037 *Patrick* (A-2150); Wier Lake, 2047 *Hodge* (A-2171). Pike County: Shohola Falls, 14 *Burke* (A-2208).

Navicula mutica Kütz., 1844, Bacill., p. 93. *pl. 3, fig. 32.*

This species was rare.

Pike County: Shohola Falls, 10 *Burke* (A-2200).

Navicula pupula Kütz., 1844, Bacill., p. 93. *pl. 30, fig. 40.*

Though found in several localities this species was only frequent in the squeezings from moss collected in the spillway of Mud Run.

Monroe County: Davy's Run, 2014 *Patrick* (A-2109), 2019 *Patrick* (A-2119); Raymondskill Falls, 2025 *Patrick* (A-2131); Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138); Pocono Lake, 2036 *Patrick* (A-2149). Northampton County: Green Pond, 2050 *Hodge* (A-2176). Pike County: 127 *Shulze* (A-2215).

Navicula pupula v. **bacillaroides** Grun. *apud* Cl. and Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 45.

I do not believe as Hustedt does that this variety and var. *rectangularis* of Grunow should be united. I have seen Cleve and Moeller's Type Slide No. 86 which has on it var. *rectangularis*. These specimens are quite distinct from those of var. *bacillaroides*. The sides of the valve are linear or somewhat concave while those of var. *bacillaroides* are somewhat convex. Also var. *bacillaroides* seems to have a more robust structure than var. *rectangularis*.

This variety was only encountered once in this study.

Northampton County: Green Pond, 2050 *Hodge* (A-2176).

Navicula pupula v. **capitata** Hustedt *apud* Pascher, 1930, Süssw. Flora Mitteleurop., Heft 10: 281. *fig. 467c.*

Though found in several localities this variety was always rare.

Monroe County: Pocono Lake Preserve, Pocono Lake, 2065 *Patrick* (A-2182); Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Shohola Falls, 11–12 *Burke* (A-2202–05). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

Navicula Rotaeana (Rabh.) Van Heurck, 1880, Syn. Diat. Belgique, *pl. 14, fig. 17.*

Stauroneis Rotaeana Rabh., 1852, Hedwigia **1:** 103. *pl. 13, fig. 7.*

Though found in many habitats this species was common only in Davy's Run. Here it was often found associated with the mosses *Hypnum* and *Fontinalis*.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Davy's Run, 2014–19 *Patrick* (A-2110–19); Pocono Lake Preserve, Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); Pocono Lake, 2035 *Patrick* (A-2147); Spring Run, 2037 *C. Myers* (A-2150); Trout Lake, 2049 *Hodge* (A-2174). Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195); Shohola Falls, 3–4 *Burke* (A-2190–92), 13 *Burke* (A-2206). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

Navicula subatomoides Hustedt, 1936, *in* A. Schmidt's Atlas der Diatomaceen-Kunde, *pl. 404, figs. 33–35.*

As this species has not been validly described I am supplying the following description.

Valvae ellipticae 6–7 μ longae, 4–5 μ latae, area axiali anguste, area centrali lata stauroneiformi; striis 44 in 10 μ, radiantibus.

This species was very common in the squeezings from *Hypnum* and *Fontinalis* in Davy's Run.

Monroe County: Davy's Run, 2019 *Patrick* (A-2119). Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195).

Navicula variostriata Krasske, 1923, Bot. Archiv. **3:** 197. *fig. 12.*

This species was rare in the localities in which it was found. Hustedt

states that it is especially found associated with *Sphagnum*. This did not seem to be necessarily the case in the habitats in which it was found in this study.

Pike County: Bushkill Creek, 1623 *Shulze* (A-2231); Greeley, 2 *Burke* (A-2188); Shohola Falls, 14 *Burke* (A-2209–10).

NAVICULAE DECIPIENTES Cleve

Navicula halophila v. **minor** Kolbe, 1927, Pflanzenforschung **7:** 67. *pl. 1, fig. 4.*

Kolbe states that this variety is a "mesohalobien." If I am correct in believing that my specimens belong to this variety, then it should be noted that this variety also is found in somewhat acid, shallow, fresh water. I have not seen any authenticated specimens of var. *minor*, but a careful analysis of Kolbe's figure would indicate that my specimens are the same. My specimens are about 17 μ long, 6 μ broad, and the striae are 19 in 10 μ.

Monroe County: Pocono Lake Preserve, South Pocono Lake, 2010 *Patrick* (A-2101); Tobyhanna Creek, 2032 *Patrick* (A-2140). Pike County: Shohola Falls, 4 *Burke* (A-2192), 11 *Burke* (A-2202).

Navicula semen Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin, **1841:** 419. *pl. 1, fig. II, 17-a?; pl. 4, fig. II, 8.*

This species was very frequent in two localities or collections of Shulze which were simply indicated as Pike County.

Monroe County: Jaggie's Bog, 262–63 *Shulze* (A-2223–25). Pike County: 128–129 *Shulze* (A-2217–19).

PINNULARIA EHRENBERG

A. Striae distinctly separated from each other.....**Distantes**
A. Striae close to each other
  B. Striae short, perpendicular or almost so to the raphe
    C. Large forms, striae typically less than 15 in 10 μ....**Brevistriatae**
    C. Small forms, striae more than 15 in 10 μ.....**Parallelestriae**
  B. Striae not perpendicular to the raphe nor typically short
    C. Raphe linear
      D. Valves with capitate or rostrate ends which are narrower than the rest of the valve, usually small forms.....**Capitatae**
      D. Valves with ends not distinctly narrower than rest of valve
        E. Striae somewhat radiant in the middle and convergent at the ends, larger forms, usually over 40 μ long **Tabellariae**
        E. Striae strongly radiant in the middle and convergent at the ends, raphe at terminal nodules bayonet-shaped **Divergentes**
    C. Raphe broad
      F. Simple .....**Maiores**
      F. Twisted .....**Complexae**

DISTANTES Cleve subgenus

Pinnularia borealis Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 420. *pl. 1, fig. II, 6; pl. 4, fig. I, 5; pl. 4, fig. V, 4.*

This species was frequent on dripping rocks at Shohola Falls. Pike County: 128 *Shulze* (A-2217); Shohola Falls, 9 *Burke* (A-2198).

BREVISTRIATAE subgenus

A. Valve triundulate, ends rostrate-capitate, axial area granular **P. nodosa**

A. Valves not triundulate

B. Valves more or less swollen at center, ends capitate, axial area granular **P. acrosphaeria** and var.

B. Valve linear, ends rounded, axial area clear.....**P. brevicostata**

Pinnularia acrosphaeria W. Smith, 1853, Brit. Diat., **1:** 58. *pl. 19, fig. 183.*

This species, though found in several localities in Pike County, was never of frequent occurrence.

Pike County: 2190 *Shulze* (A-2236), 128–130 *Shulze* (A-2217–21); Bushkill Creek, 1621 *Shulze* (A-2227); Greeley, 2 *Shulze* (A-2188); Shohola Falls, 3 *Burke* (A-2190), 13 *Burke* (A-2206), 14 *Burke* (A-2210).

Pinnularia acrosphaeria var. **turgidula** Grun. *apud* Cleve, 1895, K. Sv. Vet. Akad. Handl. **27** (3): 86.

This very distinctive species was never of frequent occurrence.

Monroe County: Pocono Lake Preserve, Pocono Lake, 2035 *Patrick* (A-2146); Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Shohola Falls, 3 *Burke* (A-2190).

Pinnularia brevicostata Cleve, 1891, Acta Soc. pro Fauna et Flora Fennica **8** (2): 25. *pl. 1, fig. 5.*

This species was only found once and then it was rare. It may have been a contamination.

Pike County: 2190 *Shulze* (A-2236).

Pinnularia nodosa (Ehr.) W. Smith, 1856, Brit. Diat., **2:** 96.

Navicula nodoso Ehr., 1838, Die Infusionsthierchen als volkommene Organismen, p. 179. *pl. 13, fig. 9.*

This species was of common occurrence in a locality given by Shulze only as Pike County.

Monroe County: Jaggie's Bog, 262 *Shulze* (A-2223). Pike County: 127–128 *Shulze* (A-2215–17); 2188 *Shulze* (A-2233); Bushkill Creek, 1621–23 *Shulze* (A-2227–31); Greeley, 1 *Burke* (A-2184); Shohola Falls, 12 *Burke* (A-2205).

PARALLELISTRIATAE Cleve subgenus

Pinnularia fasciata (Lagst.) Hustedt *apud* Pascher, 1930, Süssw. Flora Mitteleurop., Heft 10: 316. *fig. 569.*

Navicula fasciata Lagst., 1873, Bihang K. Sv. Vet. Akad. Handl. **1** (14): 34. *pl. 2, fig. 11.*

This species was rare in one locality.
Pike County: Shohola Falls, 14 *Burke* (A-2210).

Pinnularia sublinearis (Grun.) Cl., 1895, K. Sv. Vet. Akad. Handl. **27** (3): 74.

Navicula sublinearis Grun. *apud* Van Heurck, 1880, Syn. Diat. Belgique, *pl. 6, figs. 25, 26,* text (1885) p. 76.

This species was rare in the one locality given below.
Wayne County: Angels, 2017 *Burke and Patrick* (A-2115).

CAPITATAE Cleve subgenus

A. Margins of valve triundulate with central area forming a stauros
P. mesolepta v. stauroneiformis

A. Margins of valve not triundulate
B. Valves lanceolate, axial area broad
C. Valve 30 or more μ long, striae 11–12 in 10 μ
P. Braunii v. amphicephala
C. Valve 20 μ long, striae 17 in 10 μ **P. Burkei**
B. Valves linear, ends of valve distinctly capitate
D. Striae almost parallel, slightly radiate at middle and convergent at ends
E. Central area a broad fascia **P. Hilseana**
E. Central area only slightly broader than the axial area
P. subcapitata
D. Striae distinctly radiate at center of valve, convergent at ends, central area rhomboidal sometimes forming a stauros
P. interrupta
B. Valves linear, ends subcapitate
F. Striae gradually shortened to form a very broad fascia
P. subcapitata v. paucistriata
F. Striae usually abruptly shortened to form a transverse fascia
P. subcapitata v. stauroneiformis

Pinnularia Braunii v. **amphicephala** (Mayer) Hustedt *apud* Pascher, 1930, Süssw.-Flora Mitteleurop., Heft 10: 319. *fig. 578.*

Pinnularia amphicephala Mayer, 1917, Denks. K. Bayern Bot. Ges. in Regensburg **13:** n.s. **7:** 136. *pl. 2, figs. 15, 16.*

This species was only found in one locality and then it was rare.
Monroe County: Pocono Lake Preserve, Davy's Run, 2014 *Patrick* (A-2109).

Pinnularia Burkei sp. nov.

PLATE III, FIG. 1

Valvae lanceolatae apicibus rostrato-capitatis, 19 μ longae, 3 μ latae, striis 17 in 10 μ, radiantibus, apice versus convergentibus. **Type:** Pike County: Greeley, 2 Burke (A-2189).

I place this species in the Capitatae with some hesitation. It has the characteristics of the species typically included in this group except for the

axial area. Typically, this group has a narrow axial area. However, if we include *Pinnularia Brauni* v. *amphicephala* within it, I believe we are justified in including this species.

This species is named in honor of Mr. Joseph F. Burke of the New York Botanical Gardens who has given me many diatom collections from Pike County.

This species was only found in two localities.

Pike County: Greeley, 2 *Burke* (A-2188–89); Shohola Falls, 14 *Burke* (A-2210).

Pinnularia Hilseana Janisch *apud* Hilse, 1860, Jahres-Ber. Schles. Ges. Väterl. Cult. **36:** 82.

The identification of these specimens has been checked with Rabenhorst's Algen. Sachs. resp. Mitteleurop. No. 953. This species was found only in association with *Sphagnum*. Because it has this very distinctive habitat as well as definite taxonomic characters, I do not believe it wise to consider it a variety of *P. subcapitata*, but think it should be kept as a separate species.

This species was of very frequent occurrence in Lake Tamaque.

Monroe County: Pocono Lake Preserve, South Pocono Lake, 2011–12 *Patrick* (A-2103–05); shallow ditch on way to Davy's Run, 2013 *Patrick* (A-2108); Lake Tamaque, 2040 *Hodge* (A-2156).

Pinnularia interrupta W. Sm., 1853, Brit. Diat., **1:** 59. *pl. 19, fig. 184.*

Though found in several localities this species was rare.

Lackawanna County: Indian Lake, 2044 *Hodge* (A-2165). Monroe County: Pocono Lake Preserve, Davy's Run, 2014 *Patrick* (A-2110), 2019 *Patrick* (A-2119), South Pocono Lake, 2010 *Patrick* (A-2102); Wier Lake, 2046 *Hodge* (A-2169). Northampton County: Green Pond, 2050 *Hodge* (A-2176). Pike County: Greeley, 1–2 *Burke* (A-2184–88); Shohola Falls, 10 *Burke* (A-2201), 12 *Burke* (A-2204).

Pinnularia mesolepta v. **stauroneiformis** (Grun.) Cl., 1895, K. Sv. Vet. Akad. Handl. **27** (3): 76.

Navicula mesolepta v. *stauroneiformis* Grun., 1860, Verh. Zool. Bot. Ges. Wien **10:** 520. *pl. 4* (Grunow *pl. 2*) *fig. 22b.*

This variety was rare in one locality.

Pike County: 127 *Shulze* (A-2215).

Pinnularia subcapitata Greg., 1856, Quart. Jour. Micros. Sci., **4:** 9. *pl. 1, fig. 30.*

This species, as figured by Gregory, has distinctly capitate ends and an indistinct central nodule. Certainly it does not form a stauros. Some workers have confused this typical species with its variety *stauroneiformis*. They have called specimens with a stauros and subcapitate ends by the specific name. A study of Gregory's original plate will show that the diatom he was describing is distinctly different from the stauroid variety.

Monroe County: Lake Tamaque, 2039 *Hodge* (A-2154).

Pinnularia subcapitata v. **paucistriata** Grun. *apud* Van Heurck, 1880, Syn. Diat. Belgique, *pl. 6, fig. 23.*

This diatom was only found once, but then it was of frequent occurrence. Pike County: Shohola Falls, 3 *Burke* (A-2190).

Pinnularia subcapitata v. **stauroneiformis** Van Heurck, 1880, Syn. Diat. Belgique, *pl. 6, fig. 22.*

This variety was found in several habitats but was frequent in none. Monroe County: Pocono Lake Preserve, Davy's Run, 2056 *Patrick* (A-2180), Spring Run, 2037 *C. Myers* (A-2150). Pike County: Greeley, 1–2 *Burke* (A-2186–88). Wayne County: 2021 *Burke and Patrick* (A-2123), 2024 *Burke and Patrick* (A-2129).

TABELLARIAE Cleve subgenus

In many instances it is very difficult to distinguish this group from the Divergentes. As I have not studied these groups critically, I shall follow the classification of Cleve and Hustedt.

A. Valves with lunate markings on each side of the central nodule **P. stomatophora**

A. Valves without such markings

B. Valves linear, apices rounded, striae strongly radiate at center of valve, gradually shortened to form a stauros..... **P. substomatophora**

B. Valves linear or linear-lanceolate with somewhat rostrate-capitate ends **P. gibba** and var.

Pinnularia gibba Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** *pl. 1, fig. II, 8; pl. 3, fig. I, 4.*

PLATE III, FIG. 2–5

I have not been able to find the original reference to *Pinnularia gibba.* In the above cited article, Ehrenberg gives four illustrations of *P. gibba.* One illustration, *Pl. 1, fig. II, 3,* Ehrenberg questions as being this species. The other three illustrations seem to refer to two distinctly different diatoms. Two illustrations, *Pl. 1, fig. II, 8,* and *Pl. 3, fig. I, 4,* are more as the present concept of *P. gibba.* The third illustration, *Pl. 2, fig. I, 24,* is hard to identify as being any form recognized to-day. Ehrenberg also describes in the above reference, p. 423, *Pl. 1, fig. II, 3, Stauroptera gibba.* He states that this is in some ways like *P. gibba,* but is a doubtful form. I have included in my plates reproductions of Ehrenberg's figures. Ehrenberg states the magnification is 300 times.

As to my specimens, two diatoms were found which belong to the *P. gibba* series. One was like the specimens on H. L. Smith Spec. Typ. No. 275 which is probably the typical form. The specimens which I found were always in association with *Sphagnum.*

This species was very frequent in a composite collection made by Mr. Frank Myers from Pocono Lake.

Monroe County: Lost Lake, 2020 *Turner* (A-2121); Pocono Lake Pre-

serve, Pocono Lake, *F. Myers* (A-2213), South Pocono Lake, 2011 *Patrick* (A-2103).

Pinnularia gibba v. **rostrata** var. nov.

PLATE III, FIG. 6

Valvae lineares, 69 μ longae, 10 μ latae, apicibus rostratis; area axiali lata; striis 9 in 10 μ, intermediis parum radiantibus, terminalibus convergentibus. **Type:** Monroe County: Pocono Lake, *F. Myers* (A-2213).

Monroe County: Mountain Lake, 2051 *Hodge* (A-2178); Pocono Lake Preserve, Pocono Lake, 2034 *Patrick* (A-2144), *F. Myers* (A-2213); Wier Lake, 2046 *Hodge* (A-2169).

Pinnularia stomatophora (Grun.) Cleve, 1895, K. Sv. Vet. Akad. Handl. **27** (3): 83.
Navicula stomatophora Grun., 1876, in A. Schmidt's Atlas Diatomaceen-Kunde, *pl. 44, figs. 24, 26.*

Though found in several localities this species was rare in all.

Pike County: 128 *Shulze* (A-2217), 2190 *Shulze* (A-2236); Shohola Falls, 14 *Burke* (A-2208).

Pinnularia substomatophora Hustedt, 1935, Archiv für Hydrobiol. und Planktonk. Suppl. **14:** 160. *pl. 2, fig. 14.*

This species is present in several localities but frequent in none.

Monroe County: Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213); Wier Lake, 2046–47 *Hodge* (A-2169–70). Pike County: Greeley, 2 *Burke* (A-2188); Shohola Falls, 4 *Burke* (A-2192), 13 *Burke* (A-2206).

DIVERGENTES Cleve subgenus

This group seems to be closely allied to the Tabellariae and in some cases it is very hard to decide in which group a species belongs. As I have not made a critical study of these groups, I have followed the classification of Cleve.

A. Central area with a horseshoe-shaped thickening on each side of the central nodule **P. divergens** and vars.

A. Central nodule without such thickenings

B. Edge of valve triundulate ..... **P. legumen**

B. Valve linear, narrowed toward the ends

C. Length less than 25 μ ..... **P. obscura**

C. Length over 40 μ ..... **P. Brebissonii**

Pinnularia Brebissonii (Kütz.) Rabenhorst, 1864, Flora Europea Algarum, p. 222.
Navicula Brebissonii Kütz., 1844, Bacill., p. 93. *pl. 3, fig. 49; pl. 30, fig. 39.*

Kützing says that this species is the same as *Frustulia bipunctata* Breb. Cons. Diat., p. 18 (sec. specim.). Miss Hilda F. Harris has verified this reference for me, and states that no description or illustration is given. Therefore even if it is the same as *Frustulia bipunctata*, the name *Pinnularia Brebissonii* is valid.

Monroe County: Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213). Pike County: 128 *Shulze* (A-2217), 2188 *Shulze* (A-2234).

Pinnularia divergens W. Sm., 1853, Brit. Diat., **1:** 57. *pl. 18, fig. 177.*

This species though found in several localities is frequent in none.

Monroe County: Davy's Run, 2015 *Patrick* (A-2111), 2017–18 *Patrick* (A-2115–18); Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213), 2065 *Patrick* (A-2182); South Pocono Lake, 2010 *Patrick* (A-2102); Tobyhanna Creek, 2032 *Patrick* (A-2140). Pike County: 2190 *Shulze* (A-2236); Greeley, 1 *Burke* (A-2184).

Pinnularia divergens v. **parallela** (Brun) Freng., 1924, Anales Soc. Cient. Argentina **97:** 102.

Pinnularia parallella (*divergens* W. Sm. var.) Brun, 1895, Le Diatomiste **2:** *pl. 14, fig. 7.*

This species was found twice but was not frequent in either locality.

Pike County: 129 *Shulze* (A-2219), 2190 *Shulze* (A-2236).

Pinnularia legumen Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin, **1841:** *pl. 4, fig. I, 7.*

This species is also mentioned in the Ber. K. Akad. Wiss. Berlin **1843:** 255, but is not described. There may be an earlier description which I have not found. I have checked this identification with Van Heurck's Type Slide no. 69.

This species was found only in one locality and then it was rare.

Pike County: Shohola Falls, 12 *Burke* (A-2205).

Pinnularia obscura Krasske, 1932, Hedwigia **72:** 117. *pl. 3, fig. 22.*

In his description Krasske states that the striae are 10 in 10 μ. In my specimen they are 12 in 10 μ, otherwise it is the same as Krasske's description. This species was found in only one locality but there it was very frequent.

Pike County: Greeley, 2 *Burke* (A-2188).

MAIORES Cleve subgenus

Pinnularia Clevii sp. nov.

PLATE III, FIGS. 7–10

Valvae bis constrictae, 112 μ longae, ad medium 16 μ latae; apicibus leviter rostratis; costis 9 in 10 μ, centro aliquid radiantibus, in apicibus convergentibus, area axiali lata, raphe simplice lata. **Type:** Monroe County: Jaggie's Bog, 263 *Shulze* (A-2225).

This species was first observed by P. T. Cleve and for that reason I am naming it after him. In 1891 (Acta Soc. pro Fauna et Flora Fennica **8** (2): 24. *pl. 1, fig. 3*) Cleve referred this species to *Pinnularia essox* Ehrenberg. An examination of Ehrenberg's original plate (Abhandl. K. Akad. Wiss. Berlin **1841:** *pl. I, fig. II, 4*) shows clearly that these two species are not the same. Ehrenberg's *Pinnularia essox* was no doubt the same as *Navicula essox* on H. L. Smith's Species Typicae No. 272. This species

really belongs to the genus *Caloneis*. I have included a copy of Ehrenberg's and Cleve's original figures. Also I have included a photograph of one of the specimens of H. L. Smith's Species Typicae No. 272.

This species was only found in one locality.

Monroe County: Jaggie's Bog, 262–63 *Shulze* (A-2223–2225).

Pinnularia maior (Kütz.) W. Sm., 1853, Brit. Diat., **1:** 54. *pl. 18, fig. 162.*

Frustulia maior Kütz., 1833, Syn. Diat., p. 547. *pl. 14, fig. 25.*

This species was found in several localities but was frequent in none.

Monroe County: Davy's Run, 2016 *Patrick* (A-2113); Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213). Pike County: 2188–90 *Shulze* (A-2234–36); Greeley, 1 *Burke* (A-2184).

Pinnularia maior v. **transversa** (A. Schmidt) Cl., 1895, K. Sv. Vet. Akad. Handl. **27** (3): 90.

Navicula transversa A. Schmidt, 1876, Atlas Diat., *pl. 43, figs. 5, 6.*

This variety was rare in the localities where it was found.

Monroe County: Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213). Pike County: 129 *Shulze* (A-2219), 2190 *Shulze* (A-2236).

COMPLEXAE Cleve subgenus

A. Striae usually 5 or less in 10 μ

  B. Valves broader at the middle and ends, thus producing a swollen appearance **P. nobilis**

  B. Valves linear with ends slightly narrower, but broadly rounded **P. streptoraphe**

B. Striae usually more than 6 in 10 μ

  C. Valves linear, with rounded ends; ends as broad if not broader than the rest of the valve ..... **P. gentilis**

  C. Valves linear or very slightly lanceolate, gradually diminishing in width towards the ends of the valve, thus producing in some cases a slightly elliptical effect, the band across the striae very variable as to its appearance **P. viridis** and vars.

Pinnularia gentilis (Donk.) Cl., 1895, K. Sv. Vet. Akad. Handl. **27** (3): 92.

Navicula gentilis Donk., 1870–73, Nat. Hist. Brit. Diat. p. 69. *pl. 12, fig. 1.*

This species was very frequent in Jaggie's Bog, Monroe County.

Monroe County: Jaggie's Bog, 262–63 *Shulze* (A-2223–25).

Pinnularia nobilis Ehr., 1840, Ber. K. Akad. Wiss. Berlin **1840:** 214.

This species was very frequent in a collection made by Shulze which was simply designated as Pike County. It was also common in a collection from Jaggie's Bog.

Monroe County: Jaggie's Bog, 263 *Shulze* (A-2225). Pike County: 128–29 *Shulze* (A-2217–19).

Pinnularia streptoraphe Cl., 1891, Acta Soc. pro Fauna et Flora Fennica **8** (2): 23.

This species was common in a collection made by Shulze which was simply designated as Pike County.

Monroe County: Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213). Pike County: 128–29 *Shulze* (A-2217–19); Greeley, 1 *Burke* (A-2184).

Pinnularia viridis (Nitzsch) Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** *pl. 1, figs. I, 7; III, 3; IV, 3.*

Bacillaria viridis Nitzsch, 1817, N. Schrift. Naturf. Ges. Halle **3** (1): 99. *pl. 6, figs. 1–3.*

This species was very frequent in a composite sample of collections made by Myers from Pocono Lake. Actually it may not be so frequent in any single habitat.

Monroe County: Davy's Run, 2013–14 *Patrick* (A-2107–10); Jaggie's Bog, 263 *Shulze* (A-2225); Pocono Lake Preserve, Pocono Lake, *F. Myers* (A-2213); Wier Lake, 2046 *Hodge* (A-2169). Pike County: 127–29 *Shulze* (A-2215–19), 2188–90 *Shulze* (A-2234–36); Bushkill Creek, 1621 *Shulze* (A-2227); Shohola Falls, 3 *Burke* (A-2190), 12 *Burke* (A-2204).

Pinnularia viridis v. **elliptica** Meister, 1912, Beiträge zur Krypt.-Flora Schw., **4** (1): 150. *pl. 23, fig. 4.*

This variety occurred only in one locality and then it was rare.

Monroe County: Jaggie's Bog, 263 *Shulze* (A-2225).

Pinnularia viridis v. **fallax** Cl., 1895, K. Sv. Vet. Akad. Handl. **27** (3): 91.

This variety occurred only once and then it was rare.

Monroe County: Davy's Run, 2017 *Patrick* (A-2115).

Pinnularia viridis v. **sudetica** (Hilse) Hustedt *apud* Pascher, 1930, Süssw. Flora Mitteleurop. Heft 10: 335.

Pinnularia sudetica Hilse, 1860, Jahres-Berichte Schles. Ges. Väterl. Cult. **36:** 82.

As this name is older than *P. commutata* for this variety it is the one that should be used. It is doubtful to me that this form should be considered a variety of *viridis* because the raphe is simple instead of being complex as is characteristic for this group. However Grunow, Cleve, and Hustedt considered it to be. I have not as yet arrived at any definite conclusions.

This variety was very frequent in Lost Lake which is a strongly distrophic *Sphagnum* bog.

Monroe County: Lost Lake, 2020 *Turner* (A-2121). Pike County: 129 *Shulze* (A-2219).

AMPHORA CLEVE

Amphora ovalis Kütz., 1844, Bacill., p. 107. *pl. 5, fig. 35.*

Frustulia ovalis Kütz., 1833, Linnaea **8:** 539. *pl. 13, fig. 5.*

Pike County: Shohola Falls, 10 *Burke* (A-2201).

Amphora ovalis v. **Pediculus** (Kütz.) Van Heurck, 1880, Syn. Diat. Belgique, *pl. 1, figs. 6, 7,* text (1885) p. 59.

Cymbella pediculus Kütz., 1844, Bacill., p. 80. *pl. 5, fig. 8.*

This variety, like the species, was not often found in this study. It was rare and found in only two localities.

Monroe County: Wier Lake, 2046 *Hodge* (A-2168). Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195).

Amphora perpusilla Grun., 1884, Denk. Akad. Wiss. Wien **48:** 50. *pl. 1, fig. 6.*

This species was rare in one locality.

Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

CYMBELLA AGARDH

A. Central nodule with an isolated stigma or the median striae ending in an isolated punctum at the central nodule
  B. Stigma present
    C. Stigma on dorsal side, valve more or less naviculoid with the ventral margin usually swollen at the central area.....**C. sinuata**
    C. Stigma on ventral side of central nodule, valve cymbelloid **C. tumida**
  B. Stigma not present, ventral striae ending in isolated puncti, in valve view distinctly cymbelloid in shape.....**C. cistula**

A. Central nodule without an isolated stigma, ventral striae at central nodule not ending in isolated puncti
  D. Valve view distinctly cymbelloid, raphe excentric
    E. Raphe forming a straight line usually quite close to the edge of the valve
      F. Striae distinctly lineolate, ventral edge of valve straight or somewhat convex at central nodule.....**C. turgida**
      F. Striae not distinctly lineolate
        G. Terminal nodules distant from the ends of the valves, the fissure of the terminal nodule prolonged at a slight angle to the general direction of the raphe **C. scotica**
        G. Terminal nodules near the ends of the valve, fissure not prolonged as above.....**C. ventricosa**
    E. Raphe somewhat curved or arched, more distant from the ventral margin .....**C. aspera**
  D. Valve more naviculoid in shape, raphe usually only slightly excentric
    H. Small forms with indistinct central area
      I. Striae 24 or more in 10 μ.....**C. microcephala**
      I. Striae typically less than 20 in 10 μ, raphe more excentric **C. amphicephala**
    H. Larger forms with distinct central area
      J. Striae less than 10 in 10 μ, valve elliptically lanceolate **C. Ehrenbergii**
      J. Striae more numerous
        K. Ends of valve produced, apiculate..**C. cuspidata**
        K. Ends of valve produced, capitate to rostrate **C. naviculiformis**
        K. Ends only slightly produced.....**C. Hauckii**

Cymbella amphicephala Naeg. *ex* Kütz., 1849, Spec. Algarum, p. 860.

This species was rare in the various habitats listed.

Monroe County: Davy's Run, 2015 *Patrick* (A-2111), 2056 *Patrick* (A-2180); Tobyhanna Creek, 2032 *Patrick* (A-2140), 2033 *Patrick* (A-2142); Wier Lake, 2046 *Hodge* (A-2169).

Cymbella aspera (Ehr.) Herib., 1893, Diat. Auvergne, p. 69. *pl. 3, fig. 10.*

Cocconeis aspera Ehr., 1839, Ber. K. Akad. Wiss. Berlin **1839:** 30.

Though found in two of the acid lakes, this species was very frequent only in Mountain Lake in which the pH is 7.3.

Monroe County: Mountain Lake, 2051 *Hodge* (A-2178); Pocono Lake, *F. Myers* (A-2213); Wier Lake, 2046 *Hodge* (A-2169).

Cymbella cistula (Ehr.) Kirchn., 1878, in F. Cohn's Kryptogamen-Flora von Schles., **2:** 189.

Cocconema cistula Ehr. *apud* Hempr. and Ehr., 1831, Symbolae Physicae: Animalia Evertebrata Exclusis Insectis — First Series, no page number, *pl. 2, fig. 10.*

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Popomoning Lake, 2045 *Hodge* (A-2167); Trout Lake, 2049 *Hodge* (A-2175).

Cymbella cuspidata Kütz., 1844, Bacill., p. 79. *pl. 3, fig. 40.*

Though found in many habitats, this species was always rare.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131); Pocono Lake Preserve, South Pocono Lake, 2010 *Patrick* (A-2101); Tobyhanna Creek, 2032 *Patrick* (A-2140); Pocono Lake, 2036 *Patrick* (A-2149); Wier Lake, 2046 *Hodge* (A-2169). Pike County: Shohola Falls, 10 *Burke* (A-2201), 12 *Burke* (A-2205); 130 *Shulze* (A-2221); Bushkill Creek, 1621 *Shulze* (A-2227).

Cymbella Ehrenbergii Kütz., 1844, Bacill., p. 79. *pl. 6, fig. 11.*

Monroe County: Davy's Run, 2019 *Patrick* (A-2119); Jaggie's Bog, 263 *Shulze* (A-2225).

Cymbella Hauckii Van Heurck in Hauck and Richter Phykotheka Universalis No. 147. (Reference checked for me by Dr. David H. Linder)

Pike County: Shohola Falls, 12 *Burke* (A-2204), 127 *Shulze* (A-2215), 128–130 *Shulze* (A-2217–21).

Cymbella microcephala Grun. *apud* Van Heurck 1880, *pl. 8, figs. 36–39*, text (1885) p. 63.

The identification of this species was checked with Van Heurck Type Slide 211. In both habitats in which this species was found, the water was approximately pH 7.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Trout Lake, 2049 *Hodge* (A-2174).

Cymbella naviculiformis Auersw., 1861, in Rabenhorst Algen Europea, no. 1065.

This species though found in several habitats was always rare.

Monroe County: Davy's Run, 2014 *Patrick* (A-2110). Pike County: Shohola Falls, 12 *Burke* (A-2205), 127 *Shulze* (A-2215). Wayne County: Angels, 2021 *Burke* (A-2124).

Cymbella scotica W. Sm., 1853, Brit. Diat., **1:** 18. *pl. 2, fig. 25.*

This species is one of the most widely distributed of those found in this study. Its distribution in no way seems to be correlated with the acidity or alkalinity of the water. It was found in shallow water. It is of common occurrence only in Lake Pocono, and very frequent in Trout Lake.

Lackawanna County: Indian Lake, 2044 *Hodge* (A-2165). Luzerne County: Harvey Lake, 2042–43 *Hodge* (A-2160–62). Monroe County: Davy's Run, 2014 *Patrick* (A-2110), 2018 *Patrick* (A-2118), 2056 *Patrick* (A-2180); Pocono Lake Preserve, South Pocono Lake, 2010 *Patrick* (A-2101); Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); Pocono Lake, 2034–36 *Patrick* (A-2144–48); 2038 *Patrick* (A-2152), 2065 *Patrick* (A-2182). Pike County: 2188–89 *Shulze* (A-2234–35); Shohola Falls, 3 *Burke* (A-2190), 4 *Burke* (A-2192), 10–12 *Burke* (A-2201–05), 14 *Burke* (A-2208).

Cymbella sinuata Greg., 1856, Quart. Jour. Micros. Sci. **4:** 4. *pl. 1, fig. 17.*

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Wayne County: Angels, 2021–22 *Burke and Patrick* (A-2123–25).

Cymbella tumida (Bréb.) Van Heurck, 1880, Syn. Diat. Belgique, *pl. 2, fig. 10,* text (1885) p. 64.

Cocconema tumidum Bréb. *ex* Kütz., 1849, Spec. Algarum, p. 60.

The identification of this species has been checked with Van Heurck Type Slide no. 21. It was rare in the two localities given below.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195).

Cymbella turgida Greg., 1856, Quart. Jour. Micros. Sci. **4:** 5. *pl. 1, fig. 18.*

This species was rare in the various localities.

Monroe County: Trout Lake, 2049 *Hodge* (A-2174). Pike County: 2188–90 *Shulze* (A-2233, 2236).

Cymbella ventricosa Ag., 1830, Consp. Crit. Diat., part 1, p. 9.

This species, though found in many different habitats in this study, was only twice of very frequent occurrence, in Mountain Lake and in Shohola Falls.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Davy's Run, 2014 *Patrick* (A-2110), 2016 *Patrick* (A-2113), 2018 *Patrick* (A-2117), 2056 *Patrick* (A-2180); Mountain Lake, 2051 *Hodge* (A-2178); Pocono Lake Preserve, Tobyhanna Creek, 2033 *Patrick* (A-2142); Mud

Run, 2031 *Hodge* (A-2138); Pocono Lake, 2034–36 *Patrick* (A-2144–48), 2065 *Patrick* (A-2182); Popomoning Lake, 2045 *Hodge* (A-2166); Raymondskill Falls, 2025 *Patrick* (A-2021); Trout Lake, 2049 *Hodge* (A-2174); Wier Lake, 2046–47 *Hodge* (A-2168–70). Pike County: 127 *Shulze* (A-2215), 130 *Shulze* (A-2221), 2190 *Shulze* (A-2236); Bushkill Creek, 1621 *Shulze* (A-2227); Shohola Falls, 3–4 *Burke* (A-2190–92), 10 *Burke* (A-2200), 11 *Burke* (A-2202), 14 *Burke* (A-2209), 15 *Burke* (A-2211), 2190 *Shulze* (A-2236), 127 *Shulze* (A-2215), 130 *Shulze* (A-2221); Bushkill Creek, 1621 *Shulze* (A-2227).

GOMPHONEMA AGARDH

All of the species of this genus which were found in this study belong to that section of the genus which is characterized by having a punctum ending one of the median striae or present in the central area.

A. Valve distinctly asymmetrical to the transverse axis of the valve, apices distinctly different
  B. Striae at center of valve alternately longer and shorter, thus producing a radiate effect ..... **G. constrictum**
  B. Striae not alternately longer and shorter at center of valve
    C. Valve broadest at apex of valve
      D. Valve distinctly constricted just below apex **G. acuminatum**
      D. Valve gradually tapering to opposite apex **G. augur**
    C. Valve broadest below apex of valve
      E. Apex wedge-shaped, somewhat apiculate . **G. turris**
      E. Apex distinctly capitate..... **G. sphaerophorum**

A. Valve, though asymmetrical to the transverse axis, with apices not so distinctly different as above
  F. Apices of valve acute, the valve narrow and somewhat delicate in appearance **G. gracile**
  F. Apices of valve obtuse..... **G. angustatum** var.
  F. Apices of valve capitate, valve not over 30 μ long..... **G. parvulum**

Gomphonema acuminatum Ehr., 1832, Abhandl. K. Wiss. Berlin **1831:** 88.

This species was rare in all localities cited.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2161). Monroe County: Popomoning Lake, 2045 *Hodge* (A-2166); Wier Lake, 2046 *Hodge* (A-2168). Pike County: 127 *Shulze* (A-2215); Bushkill Creek, 1623 *Shulze* (A-2231); Lake Wallenpaupek tributary, 5 *Burke* (A-2195).

Gomphonema acuminatum v. **coronatum** (Ehr.) Rabh., 1864, Flora Europaea Algarum, p. 290.

Gomphonema coronatum Ehrenberg, 1840, Ber. K. Akad. Wiss. Berlin **1840:** 211.

This species was only found in one locality and there it was rare.

Pike County: Bushkill Creek, 1621–23 *Shulze* (A-2227–31).

Gomphonema acuminatum v. **pusillum** Grun. *apud* Van Heurck, 1880, Syn. Diat. Belgique, *pl. 23, fig. 19.*

Monroe County: Popomoning Lake, 2045 *Hodge* (A-2167); Mountain Lake, 2051 *Hodge* (A-2178). Pike County: 130 *Shulze* (A-2221); Shohola Falls, 14 *Burke* (A-2209). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

Gomphonema acuminatum v. **laticeps** (Ehr.) Grun. *apud* Van Heurck, 1880, Syn. Diat. Belgique, *pl. 23, fig. 17.*

Gomphonema laticeps Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin **1841:** 416.

This species was found in one habitat and there it was rare. It may well be a contamination from some other locality.

Monroe County: Mountain Lake, 2051 *Hodge* (A-2178).

Gomphonema angustatum v. **obtusatum** (Kütz.) Grun. *apud* Van Heurck, 1880, Syn. Diat. Belgique, *pl. 24, figs. 43–45.*

Sphenella obtusata Kütz., 1844, Bacill., p. 83. *pl. 9, fig. 1.*

Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195); Shohola Falls, 10 *Burke* (A-2201). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123).

Gomphonema augur Ehr., 1840, Ber. K. Akad. Wiss. Berlin **1840:** 211.

This species was very frequent in the surface vegetation of Mountain Lake. The pH was 7.3.

Monroe County: Mountain Lake, 2051 *Hodge* (A-2178). Pike County: Shohola Falls, 12 *Burke* (A-2204).

Gomphonema constrictum Ehr., 1832, Abhandl. K. Akad. Wiss. Berlin **1830:** 63.

Luzerne County: Harvey Lake, 2042 *Hodge* (A-2160). Monroe County: Mountain Lake, 2051 *Hodge* (A-2178); Popomoning Lake, 2045 *Hodge* (A-2166).

Gomphonema constrictum v. **capitatum** (Ehr.) Van Heurck, 1880, Syn. Diat. Belgique, *pl. 23, fig. 7,* text (1885) p. 123.

Gomphonema capitatum Ehr., 1838, Die Infusionsthierchen als volkommene Organismen, p. 217. *pl. 18, fig. 2.*

Monroe County: Davy's Run, 2010 *Patrick* (A-2102), 2015 *Patrick* (A-2111), 2056 *Patrick* (A-2180); Mountain Lake, 2051 *Hodge* (A-2178); Pocono Lake Preserve, Pocono Lake, 2065 *Patrick* (A-2182); Tobyhanna Creek, 2032–33 *Patrick* (A-2140–42); Popomoning Lake, 2045 *Hodge* (A-2166); Trout Lake, 2049 *Hodge* (A-2174); Wier Lake, 2046 *Hodge* (A-2169). Pike County: 2188–90 *Shulze* (A-2233–36); Bushkill Creek, 1621 *Shulze* (A-2227); Shohola Falls, 3–4 *Burke* (A-2190–92), 10–12 *Burke* (A-2200–04).

Gomphonema gracile Ehr., 1838, Die Infusionsthierchen als volkommene Organismen, p. 217. *pl. 18, fig. 3.*

Though this species was found in several habitats, it was of frequent

occurrence only in Bushkill and Tobyhanna Creeks. My specimens correspond to those illustrated by Van Heurck in the Synopsis Diatomées Belgique, but they vary from the specimens on Cl. and Möll. Type Slide no. 274 in that the central areas of my specimens are more distinctly unilateral.

Northampton County: Green Pond, 2050 *Hodge* (A-2176). Monroe County: Tobyhanna Creek, 2033 *Patrick* (A-2142); Wier Lake, 2046–47 *Hodge* (A-2169–70). Pike County: Bushkill Creek, 1621–23 *Shulze* (A-2227–31); Shohola Falls, 14 *Burke* (A-2209).

Gomphonema gracile v. **auritum** (A. Braun) Grun. *apud* Van Heurck, 1880, Syn. Diat. Belgique, *pl. 24, fig. 15*, text (1885) p. 125.

Gomphonema auritum A. Braun *ex* Kütz., 1849, Spec. Algarum, p. 68.

I have checked these identifications against Van Heurck's Type Slide no. 212 and find that my specimens agree with this variety except in the structure of the central area. In my specimens the central area is more as v. *lanceolata*, but in other respects they seem to be v. *auritum*. No doubt they are an intermediate form. I refer to the specimens from Tobyhanna Creek. In the specimens from Bushkill Creek the striae are 9 in 10 μ. Those on Van Heurck's slide have 14 striae in 10 μ. However, Cleve (K. Sv. Vet. Akad. Handl. **26** (2): 182) states that this variation is possible.

Monroe County: Tobyhanna Creek, 2032 *Patrick* (A-2140). Pike County: Bushkill Creek, 1623 *Shulze* (A-2231).

Gomphonema gracile v. **naviculoides** (W. Sm.) Grun. *apud* Van Heurck, 1880, Syn. Diat. Belgique, *pl. 24, fig. 13*.

Gomphonema naviculoides W. Sm., 1856, Brit. Diat., **2:** 98.

This variety was very frequent once and then in very shallow water on the surface of leaves in a puddle at Angels near Mill Creek. The temperature of the water was between 50–60° F.

Pike County: Shohola Falls, 10 *Burke* (A-2201). Wayne County: Angels, 2024 *Burke and Patrick* (A-2129).

Gomphonema parvulum Kütz., 1849, Spec. Algarum, p. 65.

Sphenella ? parvula Kütz., 1844, Bacill., p. 83. *pl. 30, fig. 63*.

Hustedt states that this species prefers standing water. In this study it seemed to reach its best development and to be of very frequent occurrence in shallow, cool, swift, flowing water of Davy's Run and Mill Creek.

Monroe County: Davy's Run, 2015–16 *Patrick* (A-2111–13), 2019 *Patrick* (A-2119), 2056 *Patrick* (A-2180); Pocono Lake Preserve, Pocono Lake, Mud Run, 2031 *Hodge* (A-2138); Pocono Lake, 2036 *Patrick* (A-2148), 2065 *Patrick* (A-2182); Tobyhanna Creek, 2033 *Patrick* (A-2142); Trout Lake, 2049 *Hodge* (A-2175); Wier Lake, 2047 *Hodge* (A-2170). Pike County: 127 *Shulze* (A-2215); Bushkill Creek, 1623 *Shulze* (A-2231); Lake Wallenpaupek tributary, 5 *Burke* (A-2195); Shohola Falls, 3 *Burke* (A-2190), 10–11 *Burke* (A-2201–02). Wayne County: Angels, 2021 *Burke and Patrick* (A-2123), 2026 *Burke and Patrick* (A-2134).

Gomphonema parvulum v. **micropus** (Kütz.) Cl., 1894, K. Sv. Vet. Akad. Handl. **26** (2): 180.

Gomphonema micropus Kütz., 1844, Bacill., p. 84. *pl. 8, fig. 12.*

This variety was very frequent in only one locality, in Wayne County. The habitat was in very shallow water on the surface of leaves. The temperature of the water was between 50–60° F.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Wayne County: Angels, 2022–24 *Burke and Patrick* (A-2125–29).

Gomphonema sphaerophorum Ehr., 1845, Ber. K. Akad. Wiss. Berlin **1845:** 78.

This species was only found once and then it was rare.
Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131).

Gomphonema turris Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin, **1841:** 416.

Monroe County: Mountain Lake, 2051 *Hodge* (A-2178). Pike County: Shohola Falls, 10 *Burke* (A-2201).

CYSTOPLEURA BRÉBISSON

Cystopleura has to be used instead of *Epithemia* for the latter is preoccupied by a genus of flowering plants. Species of this genus were rarely found in this study and those noted below were rare in each of the localities.

Cystopleura turgida (Ehr.) Kuntze, 1891, Revis. Gen. Plant., **2:** 891.

Navicula turgida Ehr., 1832, Abhandl. K. Akad. Wiss. Berlin, **1830:** 64.

Monroe County: Mountain Lake, 2051 *Hodge* (A-2178).

Cystopleura Zebra v. **proboscidea** (Kütz.) De Toni, 1892, Sylloge Algarum (Bacill.) **2:** 784.

Epithemia proboscidea Kütz., 1844, Bacill., p. 35. *pl. 15, fig. 13.*

This identification has been checked with Van Heurck's Type Slide no. 254. My specimens are like the specimens on this slide except the ventral margin of the valve is straight instead of being slightly arched in the center.
Monroe County: Mountain Lake, 2051 *Hodge* (A-2178).

Cystopleura Zebra v. **saxonica** (Kütz.) De Toni, 1892, Sylloge Algarum (Bacill.) **2:** 784.

Epithemia saxonica Kütz., 1844, Bacill., p. 35. *pl. 5, fig. 15.*

Monroe County: Popomoning Lake, 2045 *Hodge* (A-2166).

RHOPALODIA O. MÜLLER

Rhopalodia gibba (Ehr.) Müll., 1897, Engler's Bot. Jahrb. **22:** 65. *pl. 1, figs. 15–17.*

Navicula gibba Ehr., 1832, Abhandl. K. Akad. Wiss. Berlin **1831:** 80.

This species, though found in several localities, was always rare.
Monroe County: Mountain Lake, 2051 *Hodge* (A-2178); Pocono Lake

Preserve, Pocono Lake, 2035 *Patrick* (A-2146). Northampton County: Green Pond, 2050 *Hodge* (A-2176).

HANTZSCHIA GRUNOW

Hantzschia amphioxys (Ehr.) Grun. *apud* Cl. and Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 103.

Eunotia amphioxys Ehr., 1843, Abhandl. K. Akad. Wiss. Berlin, **1841:** 413. *pl. 1, fig. I, 26.*

This species was only found once and then it was rare.

Pike County: 128 *Shulze* (A-2217).

Hantzschia elongata (Hantz.) Grun. *apud* Cl. and Grun., 1880, K. Sv. Vet. Akad. Handl. **17:** 104.

Nitzschia vivax v. *elongata* Hantz., 1860, Hedwigia **2**(6): 35–36. *pl. 6, fig. 5.*

In the text the citation is as given above. In the explanation of the plate it is cited as *Nitzschia elongata.*

This species was very frequent in Jaggie's Bog.

Monroe County: Jaggie's Bog, 263 *Shulze* (A-2225). Pike County: 128 *Shulze* (A-2217); Shohola Falls, 12 *Burke* (A-2204).

NITZSCHIA HASSALL

A. Frustule with middle part of valve spindle-shaped, ends long attenuate **Nitzschiellae**

A. Frustule not so formed

B. Keel punctae prolonged into ribs extending over the surface of the valve **Grunowiae**

B. Keel punctae not forming ribs, valve usually not constricted in the middle, valve usually lanceolate ..... **Lanceolatae**

GRUNOWIAE (Rabenhorst) Grunow

Nitzschia sinuata v. **Tabellaria** Grun. *apud* Van Heurck, 1881, Syn. Diat. Belgique, *pl. 60, figs. 12, 13,* text (1885) p. 176.

Denticula Tabellaria Grun., 1862, Verh. Zool. Bot. Ges. Wien **12:** 548. *pl. 18* (Grunow's *plate 12*) *fig. 26.*

I have checked this determination with Grunow's determination on Van Heurck's Type Slide no. 386.

This variety was frequent in a collection which was made by squeezing out plants of *Elodea* found in Popomoning Lake.

Monroe County: Popomoning Lake, 2045 *Hodge* (A-2166).

LANCEOLATAE Grunow

A. Striae less than 20 in 10 μ, distinctly punctate..... **N. amphibia**

A. Striae more than 24 in 10 μ, keel punctae 7–10 in 10 μ... **N. Hantzschiana** and vars.

A. Striae usually more than 30 in 10 μ, keel punctae 11 or more in 10 μ **N. palea**

Nitzschia amphibia Grun., 1862, Verh. Zool. Bot. Ges. Wien **12:** 574. *pl. 12, fig. 23.*

This species was found only once and then it was very rare.
Northampton County: Green Pond, 2050 *Hodge* (A-2176).

Nitzschia Hantzschiana Rabh., 1860, Hedwigia **2:** 40. *pl. 6, fig. 6.*

Rabenhorst refers one to his Algen Sachs. resp. Mitteleurop. no. 943, but no description is furnished. He simply compares this species to others.
This species was found only once but in that habitat it was common.
Pike County: Shohola Falls, 15 *Burke* (A-2211).

Nitzschia Hantzschiana f. **subserians** Grun. *apud* Van Heurck, 1881, Syn. Diat. Belgique, *pl. 69, fig. 2.*

This form was found in only one locality, but it was common there.
Pike County: Shohola Falls, 15 *Burke* (A-2211).

Nitzschia palea (Kütz.) W. Smith, 1856, Brit. Diat. **2:** 89.
Synedra palea Kütz., 1844, Bacill., p. 63. *pl. 3, fig. 27; pl. 4, fig. 2.*

This species was found in several habitats, but was common in only one locality, Green Pond, a body of water which has a higher mineral content than the other lakes or bodies of water that were studied.
Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Northampton County: Green Pond, 2050 *Hodge* (A-2176). Pike County: Shohola Falls, 3 *Burke* (A-2190), 10 *Burke* (A-2200).

Nitzschia palea v. **debilis** (Kütz.) Grun. *apud* Cl. and Grun., 1880, K. Sv. Vet. Akad. Handl. **17** (2): 96.
Synedra debilis Kütz., 1865, Bacill., 2d ed. p. 65. *pl. 3, fig. 45.*

This variety was found only once but there it was common. It was found associated with the species.
Northampton County: Green Pond, 2050 *Hodge* (A-2176).

Nitzschia palea v. **tenuirostris** Grun. *apud* Van Heurck, 1881, Syn. Diat. Belgique *pl. 69, fig. 31*, text (1885) p. 183.

This variety was found only twice and then it was rare.
Pike County: Shohola Falls, 4 *Burke* (A-2192), 11 *Burke* (A-2202).

NITZSCHIELLAE Rabenhorst

Nitzschia acicularis (Kütz.) W. Sm., 1853, Brit. Diat. I: 43. *pl. 15, fig. 122.*
Synedra acicularis Kütz., 1844, Bacill., p. 63. *pl. 4, fig. 3.*

The specimens found were smaller than usual, being 45 μ long and 2.3 μ wide. This species was only found in one locality, and then it was rare.
Pike County: Shohola Falls, 10 *Burke* (A-2200).

STENOPTEROBIA BRÉBISSON

Stenopterobia intermedia (Lewis) Van Heurck, 1896, Treatise on the Diatomaceae, p. 374.
Surirella intermedia Lewis, 1863, Proc. Acad. Nat. Sci. Phila. **15:** 338. *pl. 1, fig. 2.*

This species was rare in one collection which was designated by Shulze as Pike County.

Pike County: 127 *Shulze* (A-2215).

SURIRELLA TURPIN

A. Valves isopolar

B. Wings clearly evident in valve view, caniculi 20 or less in 100 μ, valves linear lanceolate ..... **S. biseriata**

B. Wings clearly evident in valve view, caniculi 30 in 100 μ, valves elliptical **S. Moelleriana**

B. Wings not clearly evident in valve view

C. Caniculi 50–60 in 100 μ, ends of valve rounded... **S. gracilis**

C. Caniculi more than 60 in 100 μ, ends of valve somewhat wedge-shaped **S. angusta**

A. Valves heteropolar

D. Wings not clearly developed in valve view, apparently marginal **S. guatemalensis**

D. Wings clearly developed in valve view

E. Frustule distinctly wedge-shaped in girdle view... **S. splendida**

E. Frustule linear only slightly wedge-shaped in girdle view **S. tenera** and vars.

Surirella angusta Kütz., 1844, Bacill., p. 61. *pl. 30, fig. 52.*

Though found in several localities it was frequent in only one which was from squeezings of moss in Mud Run. From this study it would seem that this species preferred running water.

Monroe County: Davy's Run, 2015 *Patrick* (A-2111), 2017 *Patrick* (A-2115), 2056 *Patrick* (A-2180); Pocono Lake Preserve, Mud Run, 2031 *Hodge* (A-2138); Tobyhanna Creek, 2033 *Patrick* (A-2142); Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Shohola Falls, 10–11 *Burke* (A-2201–03), 14 *Burke* (A-2210). Wayne County: Angels, 2022 *Burke and Patrick* (A-2125), 2026 *Burke and Patrick* (A-2134).

Surirella biseriata Bréb., 1836, Mem. Soc. Acad. Sci. Artes Belles Lettres de Falaise, **1835:** 53. *pl. 7.*

This species was found only once and then it was rare.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131).

Surirella gracilis (W. Sm.) Grun., 1862, Verh. Zool. Bot. Ges. Wien **12:** 450. *pl. 7* (Grunow's *plate 10*) *fig. 11.*

Tryblionella gracilis Smith, 1856, Brit. Diat., **2:** 35. *pl. 10, fig. 75.* (Grunow questions that this is the same.)

This species was found only once and then it was rare.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131).

Surirella guatemalensis Ehr., 1854, Mikrogeologie, *pl. 33, fig. VI, 7.*

This species has previously been reported from Massachusetts and Connecticut. It was only found once or twice in the collection. However, since

it is such a distinct species and one not to be confused with any other, I have decided to include it.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131).

Surirella Moelleriana Grun., 1870, Catalogue and "400" Type Plate of Moeller, *2–3–10.*

As indicated above this species is recorded as a new species in the catalogue which accompanied Moeller's "400" Type Plate. It is stated that these identifications are according to the classification of Grunow. It has been generally assumed that the identifications were made by Grunow.

In some ways this species seems to be very similar to *Surirella Amphioxys* W. Smith, but until William Smith's slide is seen, this problem cannot be settled. Smith does not give a figure and his description is not complete enough to be definite.

This species was only found in one locality, but then it was of frequent occurrence.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131–33).

Surirella splendida Ehr., 1854, Mikrogeologie, *pl. 2, fig. III, 16, fig. XIV, 35, pl. 35, figs. A-1, F-6.*

This species was found only once and then it was rare.

Monroe County: Davy's Run, 2056 *Patrick* (A-2180).

Surirella tenera Greg., 1856, Quart. Jour. Micros. Sci. **4:** 11. *pl. 1, fig. 38.*

This species was found only once and then it was rare.

Monroe County: Davy's Run, 2019 *Patrick* (A-2119).

Surirella tenera v. **nervosa** A. Schmidt, 1875, Atlas Diatomaceen-Kunde, *pl. 23, figs. 15–17.*

This species was rare in the two localities cited below.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131). Pike County: Lake Wallenpaupek tributary, 5 *Burke* (A-2195).

Surirella tenera v. **Palmeri** (Boyer) Hustedt, 1927, in A. Schmidt's Atlas der Diatomaceen-Kunde, *pl. 366, fig. 4, 5.*

Surirella Palmeri Boyer, 1920, Bull. Torrey Bot. Club **47:** 70. *pl. 2, figs. 14, 15.*

This variety was fairly frequent in the one locality where it was found.

Monroe County: Raymondskill Falls, 2025 *Patrick* (A-2131).

ECOLOGICAL DISCUSSION

In the consideration of the ecological relations of the species studied, I have thought it wise to consider in detail only those species which were very frequent or common in a given habitat. It is the purpose of such an ecological discussion as this one to correlate the presence of certain species to given ecological conditions. Therefore if a species or variety is not well established in a given habitat, it cannot be typically indicative of the conditions present. It is in the taxonomic consideration that the detailed

distribution of each species is given. The pH range given in parenthesis is that which Krieger [1] has indicated for the species in question. A study of the various habitats shows the following relationships.

Lackawanna County: Indian Lake, altitude 1960 ft., pH 5–5.2, bicarbonates 8.5–11.6 p.p.m., calcium 1.54 p.p.m., color U.S.G.S. scale 10, length 0.7 kilometer. The flora was not very plentiful as to specimens or species in the collections made from this lake.

Luzerne County: Harvey Lake, Catskill formation, altitude 1230 ft., pH 7, bicarbonates 21.4–32.9 p.p.m., calcium 7.64 p.p.m., color U.S.G.S. scale 10. Length about 4 kilometers. This is the largest natural lake in Pennsylvania. It is a deep body of water of irregular outline formed by glacial action and is surrounded by wooded moraine and farming country. The principal aquatics are *Ceratophyllum demersum*, *Elodea canadensis*, *Fontinalis disticha*, *Megalodonta Beckii*, *Najas flexilis*, *Potamogeton perfoliatus*, *Potamogeton epihydrus*, *Potamogeton crispus*, *Ranunculus trichophyllus*. In the collections made from the bottom vegetation in shallow, still water, *Cyclotella compta* v. *radiosa* and *Cocconeis placentula* were the dominant forms. The collections made from the vegetation in running water at the outlet showed a more meager diatom flora.

Monroe County: Davy's Run, Pocono formation, is a mountain torrent arising on the Pocono Lake Preserve and emptying into Tobyhanna Creek. Its average pH is 5.8. The principal aquatic is *Fontinalis dalecartica*. The collections were made from several different habitats. In squeezings from *Hypnum* and *Fontinalis* growing in rapid water in deep shade, *Achnanthes linearis*, *Eunotia Meisteri*, *Fragilaria virescens* (pH 6.8–7.8), *Gomphonema parvulum* (pH 6.8–7.8), *Navicula Rotaeana*, *N. subatomoides* and *Tabellaria flocculosa* (pH 3.5–5.6) were very frequent in occurrence. Squeezings from *Fontinalis* growing in full sun in running water yielded most frequently *Achnanthes linearis*, *Eunotia pectinalis* (pH 6–7.8), *E. pectinalis* v. *minor*, *Navicula minima* v. *atomoides*, *N. Rotaeana* and *Vanheurckia rhomboides* v. *crassinervia* (pH 4–5.5). Though the observed average pH was 5.8, the species of most frequent occurrence had a minimum pH range of 3.5–6.8 and a maximum pH range of 5.5–7.8.

In a spring fed ditch six inches deep which runs along the path in the woods which leads to Davy's Run, *Vanheurckia rhomboides* v. *crassinervia* (pH 4–5.5) was commonly found. *Sphagnum* was also growing abundantly in the ditch.

Lost Lake, Pocono formation, is a strongly distrophic *Sphagnum* bog. The temperature of the water in July was between 50–60° F. The well-developed diatom flora consisted of relatively few species. Those of very frequent or common occurrence were *Eunotia robusta* (pH 4.5–5.5), *E. tautonensis*, *Pinnularia viridis* v. *sudetica*, *Vanheurckia rhomboides* and *V. rhomboides* v. *crassinervia* (pH 4–5.5). Noteworthy also was the frequent occurrence of *Asterionella Ralfsii* and the very frequent occurrence

[1] Krieger, W. 1929. Beiträge zur Naturdenkmalpflege **13** (2): 233–300.

of *Eunotia Naegelii*. The flora of this bog most nearly resembles that of Lake Tamaque which is also strongly distrophic.

Mountain Lake, Catskill formation, altitude 600 ft., length about 0.5 kilometer, pH 7–7.3, bicarbonates 41.5–68.3 p.p.m., calcium 11.71 p.p.m., color U.S.G.S. scale 25. This is a narrow pond formed by damming Pond Creek and is surrounded by open farm country. The principal aquatics are *Ceratophyllum demersum*, *Chara vulgaris*, *Elodea canadensis*, *Najas flexilis*, *Lemna minor*, and *Potamogeton epihydrus*. In the collections which were made from the surface vegetation, a well-diversified flora was present. Those species which were very frequent or abundant were *Cymbella aspera* (pH 6.8–7.8), *C. ventricosa* (pH 6.8–7.8), *Cocconeis placentula* (pH 6.8–7.8), *Eunotia monodon* v. *major*, *Gomphonema augur*, *Navicula radiosa* (pH 5–7.8) and *Synedra ulna* v. *danica*.

Pocono Lake Preserve is in the Pocono formation at an altitude of about 1640 ft. This is a large area in the Pocono Plateau which has been set aside by the state in order to preserve the native flora and fauna.

Mud Run is a small run on the preserve near Tobyhanna Creek. Squeezings from the moss growing in the spillway contained mainly *Tabellaria fenestrata* and *T. flocculosa* (pH 3.5–5.5). The pH at the time the collections were made was pH 5.2.

Pocono Lake, length about 5 kilometers, average pH 6.4, bicarbonates 15.9 p.p.m., calcium 2.37 p.p.m., color U.S.G.S. scale 40. Pocono Lake, surrounded by wooded country, is a long pond of irregular outline formed by damming Tobyhanna Creek. The principal aquatics are *Drepanocladus exannulatus* in large patches, *Eleocharis acicularis* lining areas of the shore, *Fontinalis disticha*, *Fontinalis novae-angliae*, *Myriophyllum humile* in large patches, *Najas flexilis*, *Nitella flexilis* in large patches, *Potamogeton epihydrus* adhering to submerged stumps and rocks, and *Sphagnum subsecundum*. Several collections were made from the shallow water in the vicinity of the Emlen dock. The piles supporting the dock were also scraped. The diatoms of very frequent or common occurrence were *Cymbella scotica* (pH 4.5–5.5), *Eunotia veneris* (pH 4.5–5.5), *Navicula radiosa* v. *tenella*, *Tabellaria fenestrata*, and *T. flocculosa* (pH 3.5–5.5), *Vanheurckia rhomboides* v. *crassinervia* (pH 4–5.5), and *V. rhomboides* v. *crassinervia* f. *capitata*. These findings according to the pH ranges of the species given by Krieger would mean a pH 3.5–5.5.

Collections were also made from that portion of the lake known as South Pocono Lake. The principal aquatic plant is *Sphagnum*. The pH varies from pH 5.2–5.9 depending on the direction of the wind. The main diatoms associated with the *Sphagnum* were *Eunotia robusta* (pH 4.5–5.5) and *Vanheurckia rhomboides* v. *crassinervia* (pH 4–5.5). The two diatoms were also commonly associated with *Sphagnum* in Lost Lake.

In Spring Run which empties into Pocono Lake, *Eunotia microcephala* and *E. veneris* (pH 4.5–5.5) were commonly found. The water in this run is very shallow.

Tobyhanna Creek is a rapid mountain stream from the damming of

which Pocono Lake is formed. Below the dam the stream continues and empties into the Lehigh River at Stoddartsville, Luzerne County. Collections were made from the shallow water near the banks a few hundred feet below the dam. The pH of the water was 6.4. The most common species were *Tabellaria fenestrata*, and *T. flocculosa* (pH 3.5–5.5). However a fairly diverse flora is present. The common occurrence of *Tabellaria flocculosa* at this pH is somewhat higher than typical for the species. Perhaps there is some other more important factor than pH for the successful development of this species.

Popomoning Lake (Sailor's Lake) is in Chemung formation at an altitude of 660 ft., and is about 0.7 kilometer long, pH 8–8.1, bicarbonates 33.6–34.2 p.p.m., calcium 8.82 p.p.m., color U.S.G.S. scale 15. This is a deep body of water, ovoid in shape, formed by glaciation and is surrounded by hilly wooded moraines. The principal aquatics are *Elodea canadensis*, *Najas flexilis*, and *Potamogeton foliosus*. Squeezings from the aquatics, particularly *Elodea*, yielded a fairly diverse flora with *Eunotia veneris* (pH 4.5–5.5) and *Cocconeis placentula* (pH 6.8–7.8) the principal species. Noteworthy was the frequent occurrence of *Nitzschia sinuata* v. *Tabellaria*. This was the only locality where this species was found in this study. The finding of *Eunotia veneris* in this lake was very contrary to expectations as far as pH is concerned.

Lake Tamaque is in the Pocono formation at an altitude of 1800 ft., length about 0.4 kilometer, pH 3.8–4.2, bicarbonates 6.1 p.p.m., calcium 1.21 p.p.m., color U.S.G.S. scale 170. This round pond, surrounded by hills and low forest, is formed by the damming of Beaver Creek. It is strongly distrophic. The principal aquatics are *Cladopodiella fluitans*, *Fontinalis disticha*, *Fontinalis novae-angliae*, *Myriophyllum humile*, *Sphagnum cuspidatum*, and *Utricularia vulgaris*. The flora is limited to a very few species. The most common is *Vanheurckia rhomboides* v. *crassinervia*, and of very frequent occurrence is *Pinnularia Hilseana*. In the collections taken from surface scum, *Asterionella Ralfsii* was also of common occurrence. Notable was the very frequent occurrence of *Eunotia Naegelii*. From this study it would appear that *Asterionella Ralfsii* and *Eunotia Naegelii* prefer strongly distrophic water.

Trout Lake, Pocono formation, altitude 960 ft., length about 1 kilometer, pH 6.8, bicarbonates 12.2–15.8 p.p.m., calcium 2.57 p.p.m., color U.S.G.S. scale 10. Trout Lake is an oblong pond formed by the damming of Mountain Spring Creek and is surrounded by open farming land. The principal aquatics are *Elodea canadensis*, *Najas flexilis*, and *Potamogeton epihydrus*. The diatom flora was relatively richer in *Navicula* than that of other lakes studied. The flora was fairly well diversified. The most frequent species encountered were *Cymbella scotica* (pH 4.5–5.5) and *Navicula radiosa* v. *tenella*. The finding of *Cymbella scotica* at this pH is contrary to the findings of Krieger who lists this species under the name *Cymbella gracilis*, which I have previously shown to be an invalid name for this species.

Wier Lake, Catskill formation, altitude 700 ft., length about 0.2 kilo-

meter, pH 6.6–6.8, bicarbonates 17.1–19.5 p.p.m., calcium 3 p.p.m., color U.S.G.S. scale 10. This is a roundish pond formed by damming Wier Creek which is surrounded by fairly level farming country. The principal aquatics are *Elodea canadensis*, *Fontinalis antipyretica*, and *Fontinalis disticha*. The flora is well developed as to species and specimens. In squeezings from the surface vegetation, *Eunotia monodon* v. *major*, *Stauroneis phoenicenteron* (pH 6.8–7.8), and *Synedra ulna* (pH 6.8–7.8) were of common occurrence. In collections taken from the bottom vegetation in shallow water, *Fragilaria bicapitata*, *F. elliptica*, *Navicula minima* v. *atomoides*, and *Odontidium hiemale* v. *mesodon* were very frequent or common.

Northampton County: Green Pond, Martensburg shale formation, altitude 400 ft., length about 0.1 kilometer, pH 8–8.1, bicarbonates 117.1–137.3 p.p.m., calcium 35.8 p.p.m., color U.S.G.S. scale 50. This is a small roundish body of water which is formed from old wells and springs in the center. It is surrounded by open farming country. The principal aquatic is *Najas flexilis*. As seen by the water analysis, this pond has a higher mineral content than any of the other bodies of water which were analyzed. As might be expected, the diatom flora has a decidedly different aspect than that of the other bodies of water studied. The flora is less diversified and the dominant species is *Nitzschia palea* and its variety, *debilis*.

Pike County: Bushkill Creek is located on the Catskill formation. As Bushkill Creek runs through both Pike and Monroe Counties it is doubtful in which county these collections were made. Mr. Shulze is dead and no one seems to know just where he collected. The collections were made in a spring on Bushkill Creek opposite the head of an island. A well-developed diatom flora is present. The genus *Eunotia* is the dominant genus, and the species of common or very frequent occurrence are *Eunotia flexuosa*, *Eunotia lunaris* (pH 4–7.8), *Eunotia pectinalis* (pH 6–7.8), and *Eunotia pectinalis* v. *undulata*. Thus it would seem from the diatoms that the pH was probably between 6–7.8.

The swamp at Greeley is on the Catskill formation. Collections from *Fontinalis* in the brook running through the swamp contained a flora fairly rich in *Eunotia* and *Pinnularia*. However, the only two species of very frequent occurrence were *Fragilaria virescens* (pH 6.8–7.8) and *Meridion circulare* (pH 6.8–7.8). Collections from *Sphagnum* were also rich in *Eunotia*. The most frequent species were *Eunotia septentrionalis*, *E. tenella*, *Navicula festiva*, and *Pinnularia obscura*.

The collections made at Shohola Falls, which is on the Catskill formation, were from a variety of habitats offered by a pond, a brook, and a fall. Also just below the falls is a gorge in a limestone outcrop. The flora in the gorge is distinctly different from that found in the other habitats of this region. In collections taken from the edge of the pond above the falls, the following species were common or very frequent, *Eunotia flexuosa*, *E. lunaris* (pH 4–7.8), *Melosira italica* (pH 6.5–7.8), *Tabellaria fenestrata*, and *Tabellaria flocculosa* (pH 3.5–5.5). From the moss and algae in the brook

the following species were very frequent or common: *Cymbella ventricosa* (pH 6.8–7.8), *Eunotia lunaris* (pH 4–7.8), *Eunotia veneris* (pH 4.6–5.5), *Fragilaria crotonensis*, and *Synedra ulna* v. *danica*. From the moss in swift water at the top of the falls, the species of very frequent occurrence were *Cocconeis placentula* v. *lineata* (pH 6.8–7.8), *Eunotia pectinalis* v. *undulata*, *Navicula radiosa* v. *tenella*, and *Synedra ulna* v. *danica*. In the algae at the top of the falls, the species of very frequent occurrence were *Eunotia veneris* (pH 4.5–5.5), *Meridion circulare* (pH 6.8–7.8), and *Navicula radiosa* v. *tenella*. In the scrapings from dripping rocks to one side of the falls the species of very frequent occurrence were *Eunotia lunaris* (pH 4–7.8), *E. pectinalis*, *E. pectinalis* v. *undulata*, *E. veneris* (pH 4.6–5.5), *Meridion circulare* (pH 6.8–7.8), *Navicula minima* v. *atomoides*, *Navicula placentula*, *Tabellaria fenestrata*, and *T. flocculosa* (pH 3.5–5.5).

Below Shohola Falls there is a limestone outcrop. The diatom flora found here is different from that of other habitats and clearly reflects the difference of its geological and ecological environment. Collections made from the dripping rocks facing the falls contained mainly *Nitzschia Hantzschiana*, and *Nitzschia Hantzschiana* f. *subserians*. Other collections made from dripping rocks of the side wall of the gorge further down stream but above the concrete bridge, contained as the dominant species: *Eunotia lunaris* (pH 4–7.8), *Melosira roeseana* v. *epidendron*, *Navicula Keeleyi*, and *Navicula perpusilla* (pH 6.8–7.8).

Wayne County: Mill Creek, altitude 1800 ft. Mill Creek is a rapid mountain stream located in the Catskill formation, and empties into the Paupack Creek. Enmeshed in the moss growing in the cool, shallow, swift water in the middle of the creek, *Achnanthes lanceolata* (pH 6.8–7.8), *Gomphonema parvulum* (pH 6.8–7.8) and *Meridion circulare* (pH 6.8–7.8) were very frequent. Growing on the stones in the swift water in the middle of the creek was *Cocconeis placentula* v. *lineatus* which was of very frequent occurrence. In the slow running water of a shallow tributary of Mill Creek, *Achnanthes lanceolata* (pH 6.8–7.8), *Meridion circulare* (pH 6.8–7.8), *Odontidium hiemale* v. *mesodon*, *Synedra ulna* v. *danica* and *Vanheurckia rhomboides* v. *amphipleuroides* were of very frequent occurrence. From the surface of dead leaves in very shallow water, *Achnanthes lanceolata* (pH 6.8–7.8), *Fragilaria virescens* (pH 6.8–7.8), *Gomphonema gracile* v. *naviculoides* (pH 4.5–5.6), *Gomphonema parvulum* v. *micropus*, *Meridion circulare* v. *constricta* and *Odontidium anceps* were very frequent. The temperature of the water was between 50–60° F.

It is interesting to note that though geographically these habitats are relatively close together, the dominant species are so variable. This is but another indication of how dependent the luxurious growth of a diatom is upon its immediate ecological habitat. Thus the more accurate information we have as to the requirements of each species the more valuable the diatom will be as an indicator of water conditions.

As pointed out by Hustedt,[2] certain diatoms seem to be found typically associated with moss. In this study *Eunotia Meisteri*, *E. microcephala*, *Fragilaria virescens*, *Navicula Rotaeana* and *Navicula subatomoides* were most often associated with *Hypnum* and *Fontinalis*. Those species which reached their best development in association with *Sphagnum* were *Eunotia robusta*, *Vanheurckia rhomboides* v. *crassinervia*, *Navicula festiva*, *N. quadripartita* and *Pinnularia obscura*. This study supports the conclusions of Hustedt that they are typically aerophils as usually the moss was in a partially submerged habitat. In this group of aerophils is *Fragilaria bicapitata*, but in this study it was not found typically associated with moss. Other diatoms found in this study which seem to flourish in moss on dripping rocks or in partially submerged habitats are *Melosira roeseana* v. *epidendron*, *Navicula Keeleyi* and *Tabellaria flocculosa*.

The genus *Vanheurckia* is interesting as an acidophil group. *Vanheurckia rhomboides* and *V. rhomboides* v. *crassinervia*, and *V. rhomboides* v. *crassinervia* f. *capitata* are found in various habitats. *V. rhomboides* v. *crassinervia* is one of the few diatoms which seems to thrive in strongly acid or distrophic water. *V. rhomboides* v. *amphipleuroides* on the other hand reaches its best development in much less acid water.

Three other diatoms which seem to reach their best development in strongly distrophic conditions are *Pinnularia Hilseana*, *Asterionella Ralfsii* and *Eunotia Naegeli*.

On the other hand *Nitzschia palea* and *Nitzschia palea* v. *debilis* were only found under alkaline conditions. Likewise *Nitzschia Hantzschiana* v. *subserians* was only found in association with a limestone outcrop. It might appear that *Melosira roeseana* v. *epidendron* also prefers water of a high mineral content. However, Mr. F. J. Keeley tells me that he has found *Melosira roeseana* v. *epidendron* growing on crystalline rocks. He believes that it is the habitat of dripping rocks in association with moss that is the crucial point.

Certain diatoms considered in this study were most typically found growing on rocks in shallow water. *Achnanthes lanceolatum*, *Cocconeis placentula* v. *lineata*, and *Gomphonema parvulum* seemed to prefer rocks in swift water, while *Navicula perpusilla* reached its best development on dripping rocks.

Interesting also was the very frequent occurrence of *Synedra ulna* v. *danica* in the running water of brooks. This variety has most often been reported in the flora of lakes or ponds.

It will be noted that in some cases the water was studied from a chemical standpoint. These were the bodies of water which Myers (Proc. Acad. Nat. Sci. Phila. **94:** 251–287. 1942) studied particularly in his work on the rotifers of this region. The chemical analyses were made to determine the pH, the amount of bicarbonates, and calcium. The richest diatom flora as to number of species present was between the pH ranges of 6.4–7.3. Lake

[2] Hustedt, F., 1934. Abhandlungen und Vorträge herausgegeben von der Bremer Wissenschaftlichen Gesellschaft. **8/9:** (1934) 362–403.

Tamaque with a pH of 3.8–4.2, on the other hand, had a well-developed flora consisting of only a few species. The same tendency as to fewness of species was also noted in Green Pond with a pH of 8–8.1.

It is interesting to compare the floras of Green Pond and Lake Popomoning. Both bodies of water have a pH of 8–8.1, but the mineral content of the water of Green Pond, as seen by the bicarbonate and calcium determinations, is much greater. The diatom floras are also distinctly different. As might be expected this would seem to indicate that the type of diatom flora is more closely correlated to mineral content than to pH.

As the waters considered in this study are mostly acid, it is interesting to compare them with the acid water floras of New Jersey. Though similar in many respects, certain apparent lacks are of interest. For instance the genus *Anomoeoneis*, so commonly found in New Jersey, was not found in this study. Also certain species of *Surirella* described by Lewis from the White Mountains and frequently found in New Jersey were scarcely present in this study. Also the diatom *Tibiella punctata*, which is characteristically found in New Jersey was only found once, in Pocono Lake. This record was not included, as I believe it might have been contamination since the collection was made with apparatus often used in New Jersey. However, I must add that there is no reason so far as I know why it should not be found in the Pocono region.

Interesting also to note is the occurrence of *Eunotia tautonensis* which was originally found in New England and to date has not been reported from New Jersey.

Generally speaking the diatom flora is that of a cool temperate region. It contains more species common to northern or mountainous regions than to the more moderate temperate regions.

SUMMARY

In this study two hundred forty-eight nomenclatorial entities were considered and studied. Fifteen of these are new.

The names of three species and one variety were validated by supplying an adequate description.

The ecological factors which seem to be beneficial to the development of the various species have been considered in the ecological discussion.

As this study is mostly concerned with the study of the diatom floras in moss and more or less acid water, the genera *Eunotia*, *Tabellaria*, *Vanheurckia* and certain sections of the genus *Navicula* are most abundant from a quantitative and qualitative standpoint. The genus *Pinnularia* reaches its best development in collections from Pike County, particularly in those collections made by Shulze. However, two Monroe County habitats — Pocono Lake and Jaggie's Bog — have a fairly rich *Pinnularia* flora. Several genera such as *Achnanthes*, *Cymbella*, *Gomphonema*, *Neidium* and *Surirella* are fairly well represented as to number of species present, but seldom are these species of very frequent or common occurrence in the flora.

As might be expected, the genera *Amphora*, *Diploneis* and *Nitzschia* are

not well represented. Species of the genus *Nitzschia* are common only in Green Pond and in moss at the limestone outcrop below Shohola Falls, which have a relatively high mineral content.

It is interesting to note the complete absence of the genus *Anomoeneis*, *Tibiella*, and some of the species of *Surirella* which are often found in acid water floras. Likewise some of the species of the genera *Cystopleura* and *Rhopalodia*, which are considered by some to be aerophils, are poorly represented.

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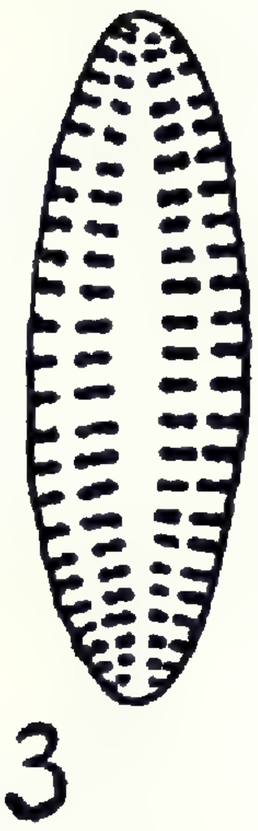
PLATE I

1. Eunotia tenella (Grun.) Hustedt x2000
2, 3. Achnanthes Lewisiana sp. nov. x2633
4, 5. Achnanthes lanceolata v. apiculata var. nov. x2500
6, 7. Achnanthes Oestrupii v. parvula var. nov. x2617
8. Navicula exigua v. capitata x2100

1

2



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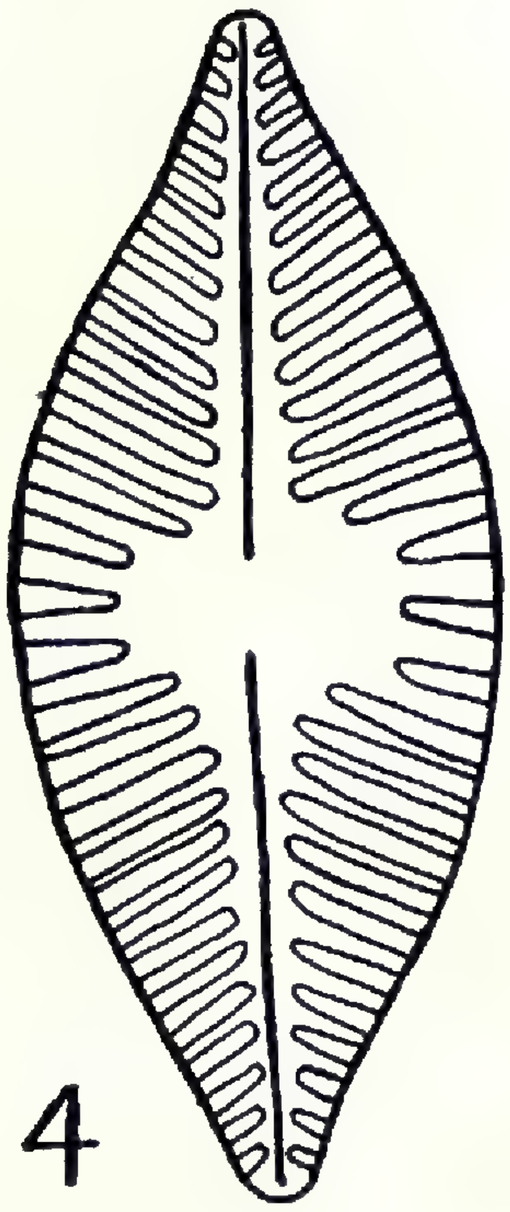

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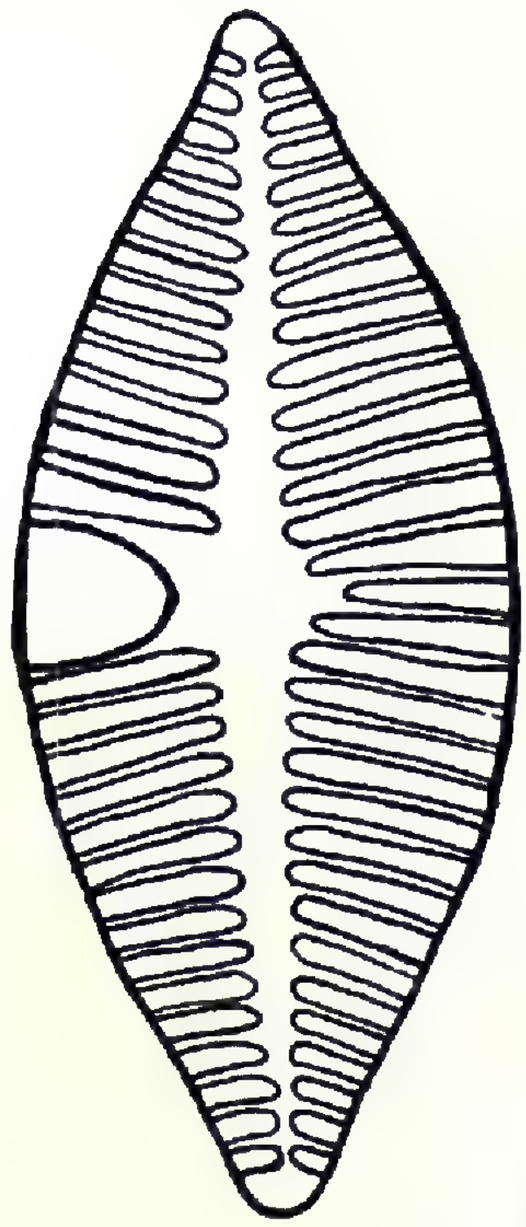

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PLATE I

PLATE II

1. Achnanthes Stewartii sp. nov. x3031
2. Achnanthes Stewartii sp. nov. x1719
3. Achnanthes Stewartii sp. nov. x2200
4. Caloneis Lewisii sp. nov. x2100
5. Navicula poconoensis sp. nov. x2537
6. Navicula concava sp. nov. x2036
7. Navicula Keeleyi sp. nov. x2160

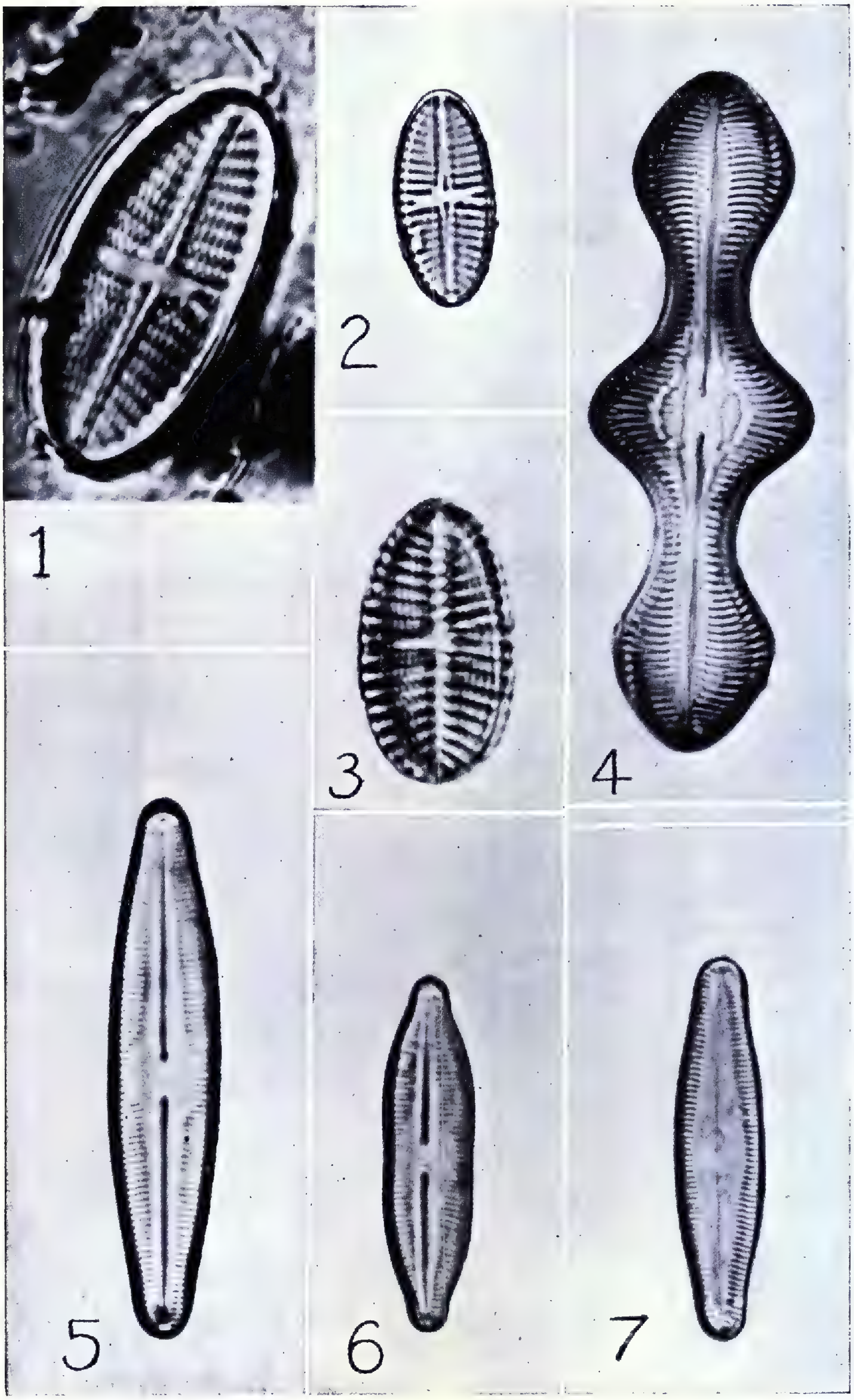

PLATE II

PLATE III

1. Pinnularia Burkii sp. nov. x2526
2, 3, 5. Pinnularia gibba, Ehrenberg's illustration x300
4. Stauroptera gibba, Ehrenberg's illustration x300
6. Pinnularia gibba v. rostrata var. nov. x1500
7. Pinnularia essox as on H. L. Smith's slide x800
8. Pinnularia essox, Ehrenberg's illustration x300
9. Pinnularia Clevei sp. nov. x598
10. Pinnularia essox as illustrated by Cleve x500

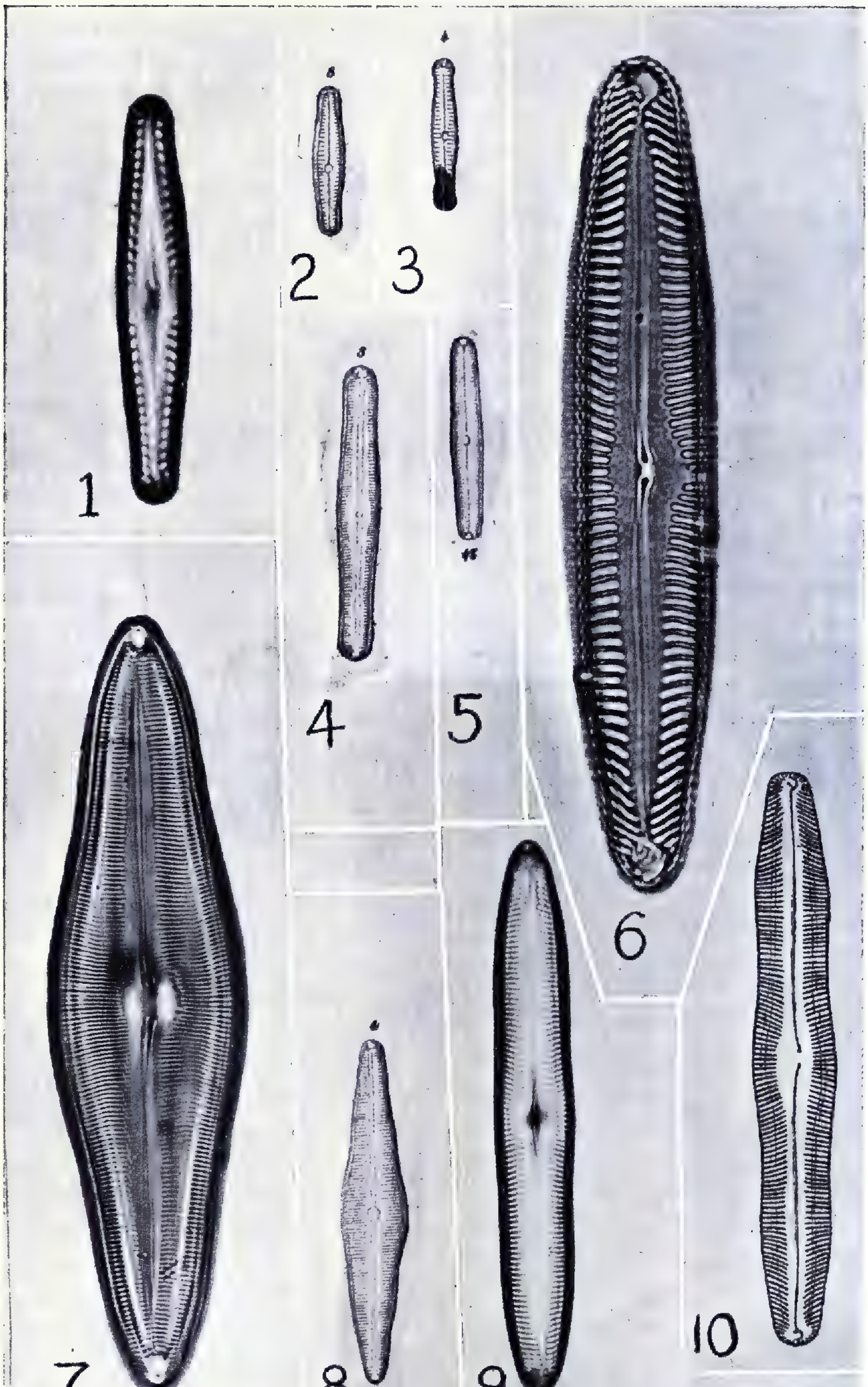

PLATE III

2(2):223–303 FARLOWIA JULY, 1945

THE BOLETINEAE OF FLORIDA WITH NOTES ON EXTRALIMITAL SPECIES

II. THE BOLETACEAE (GYROPOROIDEAE)

R. SINGER

The Boletaceae are the largest family of the suborder Boletineae. Much attention has been paid to them since Linné's day because of their edible qualities. In recent years the practical aspect has shifted to another problem, their physiological relationships with forest trees, and the economic significance of mycorrhizal symbiosis in forestry. It is obvious that no actual progress toward practical evaluation of the complicated biology of the mycorrhiza will be made without a profound knowledge of the taxonomy of the Boletaceae and extensive, accurate field observations concerning their ecological characters.

The present paper is an attempt to contribute to the knowledge of the Boletaceae of the state of Florida. Being a continuation of the first part treating the Strobilomycetaceae of Florida,[1] this article is based upon the same concept as the foregoing part, and the reader is referred to the introduction to that paper.

BOLETACEAE R. Maire (1901)

Characters of the family: Pileus scaly, fibrillose, mealy, tomentose, granulose, velutinous, or glabrous, often becoming tessellate-rimose, viscid or dry, small to large, the margin sometimes projecting; hymenophore tubulose, rarely lamellate (in *Phylloporus*); tubes short to long, decurrent or adnate to depressed around the stipe, or free; pores very small or closed when quite young to very wide and open from the beginning, sometimes lamellately arranged ("boletinoid"), and then not so easily separated from the context of the pileus, usually very easily separable from the context, in one genus (*Ixechinus*), all the single tubes free from each other, discolorous, or more frequently concolorous with the pores, whitish to sordid, or whitish to yellowish, or yellow to golden yellow, more rarely orange or red, the pores sometimes orange to red or reddish brown, at last often olivaceous or yellowish brown, sometimes becoming dirty livid or brownish or blue to green on pressure; spore print olivaceous to deep olivaceous, cinnamon, or fawn color to vinaceous pink, or ochraceous, or lemon yellow; spores usually not very richly colored under the microscope even when quite mature (except in *Xanthoconium* where they are bright golden), most fre-

[1] Singer, R. The Boletineae of Florida with notes on extralimital species. I. Farlowia **2** (1): 97–141. 1945.

quently pale melleous to melleous or brownish melleous, or pale yellowish, even hyaline, always smooth with homogeneous walls which rarely reach 1 μ in diameter, their length rarely over 20 μ, usually well below 20 μ, without germinative pore, with globose, subglobose, short-ellipsoid, fusoid-subcylindric, fusoid-ellipsoid, ovoid-fusoid, or cylindric outline; basidia and cystidia usually comparatively small, more rarely large; trama of the tube walls more or less bilateral in youth, in some genera (*Phylloporus*, *Xerocomus*) subregular, without an interlaced hymenopodium; hyphae with or without clamp connections; stipe cylindric, attenuate or thickened toward the base, or ventricose to bulbous, smooth, and glabrous or ornamented with glandulae, with furfuraceous floccons, with scabrous squamulae, or with reticulate lines, solid to hollow; veil often present, and then membranaceous, or membranaceous-floccose, or glutinous, or pulverulent (and then mostly yellow), either fugacious or persistent as an annulus on the stipe; habitat: on earth, more rarely on decayed wood in wooded areas, one species (*Xerocomus parasiticus*) parasitic on *Scleroderma*, the majority symbiotic with forest trees, forming mycorrhiza. Type genus *Boletus* Dill. *ex* Fr.

It has already become a commonplace to state the desirability of a partition of the once all-embracing genus *Boletus* into smaller units. Yet the existing schemes proposed by W. A. Murrill and E. Gilbert respectively (the remaining classifications are either stubbornly Friesian, or they have not been accepted by the mycologists, or they are merely variations of Gilbert's arrangement) were satisfactory only in a very limited way. Murrill's classification was satisfactory at a time when a system had to be mainly workable, i.e. an easy road leading to a generic name. While Murrill's classification was mostly original, Gilbert's scheme is merely an emendation and modernization of Quélet's classification (1886–1888). Although Gilbert expressly detests the evolutionary approach, he is more alluring to the phylogenetically minded modern mycologist because, at the expense of clear-cut divisions, he reunites mostly natural groups, or, at least, seems to have the tendency to do so. The real test came when additional anatomical and also chemical [2] characters were used to check on its principles and on its definition of genera, and when more facts on the richer boletaceous flora of North America and other extra-European regions became available to test its value. It cannot be denied that after careful examination of the resulting data, most of Gilbert's definitions and some of his genera have become untenable; others are complex or collective, and many of the species cited by him will have to be transferred to other groups than those designated for them by that author. As a whole, Gilbert's classification, quite in contrast to its author's claim, is a locally limited or, more accurately, a European system. When checked merely with European material, and by using only the limited number of characters admitted by Gilbert, it does

[2] Since chemical characters are not available for all species of the Boletaceae, they do not appear much in the keys of this paper. I expect them, however, gradually to take an important place in scientific keys to genera as well as to the sections and species.

not reveal many weak points, however, and this is the reason why it has been adopted with some modifications by most French authors, by this writer in his "System der Agaricales," and, in the absence of anything better, even by the most competent American specialist, W. H. Snell (Mycologia **33:** 415. 1941).

The first step toward a more universal solution, based not only on macroscopical and spore characters but on all anatomical, chemical and physiological characters available, was made by this writer in his essay on a group of genera he had studied in Siberia and compared with European and North American species: *Suillus (Ixocomus)*, *Boletinus*, *Phylloporus*, *Gyrodon*.[3] *Gyroporus* is an easily defined genus. Consequently there was left mainly the genus-complex around *Boletus sensu stricto*, i.e. the genera *Xerocomus*, *Pulveroboletus*, *Boletus*, *Tylopilus*, *Leccinum*, and besides some genera that had more recently been described from the tropics and subtropics: *Gastroboletus*, *Phlebopus*, *Ixechinus*, *Boletochaete*, *Phaeogyroporus*, and *Xanthoconium*. As for the genera *Phlebopus*, *Phaeogyroporus*, and *Xanthoconium*, the author was able to secure all data necessary to insert these genera in any new classification; the genera *Gastroboletus*, *Ixechinus*, and *Boletochaete*, however, are in need of one or two descriptive details in order to receive their place in the system. We have attempted to reorganize the species belonging to all the above-mentioned genera in order to make these genera more natural and, at the same time, provide a more precise delimitation between them enabling the student actually to determine the genus prior to determining the species. These determinations are not easy, for in order to get down to the name, it is necessary to provide many more data on a given specimen than was hitherto required. But, provided the data are available, no guesswork will be necessary, and the keys should lead smoothly to the correct genus and species. The delimitation of the genera will be more fully discussed in its proper place. In the end, no verbal justification will make a classification acceptable. The actual test will be in the laboratories and herbaria. In order not to complicate unnecessarily the determination of the genera of Florida boletes by providing one key to all known genera, we thought it wise to add a second key for use in Florida only. This latter key is partly artificial, and takes into consideration only the characters of species treated as occurring in Florida in this paper.

SURVEY OF THE SUBFAMILIES AND GENERA OF THE BOLETACEAE

A. Group of genera imperfectly known but admitted because of the presence of some important character or correlated characters. (See B1, B2, B3)

B 1. Setae present in the hymenium. Africa and Asia. *Boletochaete*

B 2. Tubes separated from each other, free. Madagascar. *Ixechinus*

[3] Singer, R. Les genres Ixocomus, Boletinus, Phylloporus, Gyrodon et Gomphidius. Rev. de Mycol. **3:** 35–53, 157–177. pl. 4. 1938.

B 3. At least part of the surface layer of the pileus and the stipe connected and including the young hymenophore like a peridium. South-China.
Gastroboletus

A. Genera completely known anatomically and chemically, not showing any of the characters indicated under B1, B2, or B3.

C. Clamp connections constantly present except in occasional parthenogenetic forms, and easy to observe on at least a fair percentage of the septa [4] (Species with elongate spores *and* large incrusted cystidia, forming mycorrhiza with conifers, and macroscopically characterized by having boletinoid hymenophores, are *not* included in this subfamily.) Subfam. *Gyrodontoideae*

D. Hymenophore depressed or subfree around the apex of the stipe, not arcuate-decurrent.

E. Spore print yellow. 1. *Gyroporus*

E. Spore print olive brown. 2. *Phaeogyroporus*

D. Hymenophore more or less arcuate-decurrent.

F. Veil present; cystidia rather distinct. 3. *Paragyrodon*

F. Veil none; cystidia usually very rare and inconspicuous. 4. *Gyrodon*

C. Clamp connections either not constant in a genus (*Boletinus*) or very sparse (not more than 1–10 clamps per 100 septa), or persistently lacking.

G. Hymenophore either boletinoid (lamellately arranged, radiately elongate pores, adnato-decurrent or deeply decurrent), or covered by a viscid-membranaceous or glutinous veil, or stipe with glandulae, or at least pileus (not stipe except, possibly, for the veil) strongly viscid (this latter character has to be combined with small, pale melleous, elongate spores, large, incrusted cystidia and cylindric or subcylindric stipe; — if not showing these additional characters, the species is *not* included in this subfamily). All species exclusively connected with coniferous trees by mycorrhiza (species forming mycorrhiza with frondose trees, or not forming mycorrhiza with Gymnospermae *only*, are *not* included in this subfamily). Subfam. *Suilloideae*

H. Veil none; stipe somewhat hollow; hymenophore more lamellately arranged near the margin than near the stipe; pileus not viscid. 5. *Psiloboletinus*

H. Veil present or absent; stipe hollow or solid; hymenophore, if arranged lamellately at all, more so toward the stipe than at the margin of the pileus; pileus viscid or dry; fungi not combining the characters indicated for *Psiloboletinus*.

I. Veil present; pileus dry, or rarely becoming viscid during its development, starting from the margin, fibrillose or scaly or floccose, these ornamentations or coverings being part of the cuticle proper, not the veil; stipe always without glandulae; hymenophore usually very strongly boletinoid, never composed of fine (diameter 0.5 mm. and less) pores; clamp connections present in many species. 6. *Boletinus*

I. Veil present or absent; if there is a veil, the pileus is never scaly or squamulose, or/and the hymenophore is composed of fine pores; pileus always viscid; glandulae frequently present on the stipe, and sometimes on the

[4] Use the mycelioid base of the stipe, or one of the cortical layers for examination. For further technical hints see Singer, Lloydia **5:** 98. 1942.

pores; hymenophore boletinoid or not boletinoid; clamp-connections none. 7. *Suillus*

G. Hymenophore not boletinoid; veil, if present at all, either glutinous or pulverulent and then yellow (yellow-green, reddish-yellow) and dry; stipe without glandulae; pileus viscid or not; species forming mycorrhiza with conifers or frondose trees; or possibly not forming mycorrhiza.

K. Lateral stratum of the hymenophoral trama of the *Phylloporus*-type (its hyphae only slightly divergent, rather close, and only little paler, if at all so, than the mediostratum, often becoming irregular in age); hymenophore made up of lamellae, or of tubes, the tubes usually wide (about or above 1 mm. in diameter); spore print olive brown, never pinkish, nor ferruginous-ochraceous, nor avellaneous-ochraceous, nor cinnamon-isabelline. Subfam. *Xerocomoideae*

L. Hymenophore lamellate. 8. *Phylloporus*

L. Hymenophore tubulose. 9. *Xerocomus*

K. Trama truly bilateral-divergent (*Boletus*-type) when young, (lateral stratum loosely arranged, strongly divergent, much paler than the mediostratum, usually hyaline, but its hyphae becoming stretched from rapid longitudinal growth of the tubes shortly before full maturity, and then becoming parallel with the mediostratum); hymenophore always made up of tubes with either wide or small pores; spore print not always olive brown. Subfam. *Boletoideae*

M. Stipe *not* combining the following characters: tapering from the base or more rarely from the middle to a slender apex, of fibrous-hard context, with scabrous squamulae or furfuraceous dots which usually are darker than the remaining surface of the stipe, or becoming so in age; pores small or wide, red or concolorous, free or adnate; mycorrhiza with frondose trees or with coniferous trees, or possibly no mycorrhiza formed.

N. Spore print consistently brownish with an olivaceous tinge.

O. Veil present or absent; if the veil is present, it consists of a yellow (yellowish-green, reddish-yellow) pulverulence, or it is entirely glutinous; if the veil is absent, the stipe is viscid in fresh, young specimens, or the pileus is covered by a yellow pulverulence; rarely, in avelate forms, there is no pulverulence and the stipe is not viscid; in this case the cuticle of the pileus is viscid; in old or dried specimens the hymenophore often assumes a very deep golden yellow, or golden olive, or reddish orange color.

P. Hymenophore a thin to medium thick layer of decurrent tubes, arcuate at least when young; stipe frequently swollen ventricose and sometimes furrowed at the base where it is continued into a dense mycelial growth which often takes the shape of a

pseudomycelium; context frequently turning blue on exposure; veil none; size of the carpophores often remarkable. 10. *Phlebopus*

P. Hymenophore consisting of rather long tubes, not decurrent, either adnate or depressed around the stipe, either applanate or convex beneath; stipe usually not swollen-ventricose, mostly more or less cylindric, or slightly thickened downwards; pseudosclerotium none; context rarely turning blue on exposure, and, if it does, there is a yellow pulverulent veil present. 11. *Pulveroboletus*

O. Veil none; stipe not viscid; pileus not covered with yellow pulverulence; if the pileus is viscid, or the base of the stipe covered with abundant yellow mycelium, the cuticle is made up of a trichodermium-pallisade or epithelium. 12. *Boletus*

N. Spore print not showing a trace of an olivaceous tinge even if it is quite fresh.[5]

Q. Spore print rusty-yellow; spores bright golden under the microscope, long-cylindric, bacilliform, and narrow; stipe smooth and glabrous; context white, unchanging, mild. 13. *Xanthoconium*

Q. Spore print deeper ferruginous, or wood brown, or fawn color, or pinkish vinaceous, not golden under the microscope, not exactly cylindric in their majority, or rarely so; stipe rarely smooth and glabrous as well; context rarely white and unchanging, and mild as well. 14. *Tylopilus*

M. Stipe (though somewhat variable in shape) mostly tapering upwards from the base or more rarely from the middle, beset with darker (or becoming darker) furfuraceous or squamulose scabrosities, rather fibrous-hard in the larger lower part but tender-fleshy in the apex, the scabrosities consisting of dermatobasidia, dermatopseudoparaphyses, and dermatocystidia, forming a terminal hymenium on a fascicle of parallel hyphae; pores very small, never red; tubes long, especially in the middle between the stipe and the margin of the pileus, deeply depressed-free around the stipe; mycorrhiza almost constantly with trees of the orders Fagales and Salicales. 15. *Leccinum*

* * *

[5] The spore print should be examined immediately after a thick layer of spores on white paper — without the hymenophore of the specimen touching it — has been obtained, and the correct equivalent in Ridgway must be noted. Old spore prints change their color.

KEY FOR DETERMINATION OF THE GENERA OF BOLETACEAE OCCURRING IN FLORIDA

A. Clamp-connections present (choose this alternative even if they are very scarce).

B. Hymenophore depressed around the stipe; spore print yellow. 1. *Gyroporus*

B. Hymenophore decurrent; spore print brownish.

C. Hymenophore lamellate. 8. *Phylloporus*

C. Hymenophore tubulose. 4. *Gyrodon*

A. Clamp-connections none.

D. Veil present.

E. Veil yellow, pulverulent. 11. *Pulveroboletus*

E. Veil not yellow, and not pulverulent.

F. Veil viscid in wet weather; pores not radiately arranged (i.e. not boletinoid); pileus viscid when wet; stipe with glandulae, rarely without them (and then the veil mostly rudimentary, only marginal). 7. *Suillus*

F. Veil dry, even in wet weather; pores radiately arranged (boletinoid); pileus non-viscid; stipe without glandulae. 6. *Boletinus*

D. Veil none.

G. Hymenophore lamellate. 8. *Phylloporus*

G. Hymenophore tubulose.

H. Spore print brown with an olive tinge, or decidedly olive.

I. Cuticle of the pileus with a distinct epithelium, consisting of several layers of spherocysts which are usually arranged in erect chains, later becoming free, and eventually often washed off; hymenophore depressed around the stipe, pores small, yellow; stipe more or less furfuraceous or squamulose-scabrous. 15. *Leccinum*

I. Pileus without a distinct epithelium.

J. Stipe fibrous-fleshy and rather hard, gray to black squamulose-scabrous on white to pale grayish ground; context white, changing to sordid lilac on exposure. 15. *Leccinum*

J. Stipe not scabrous and usually soft-spongy-fleshy; context white or colored, changing or unchanging.

K. Pileus with a yellow pulverulence, *or* stipe with glandulae, *or* stipe viscid, *or* hymenophore arcuate-decurrent when young with the tubes rather short to barely medium long.

L. Glandulae present on the surface of the stipe; mycorrhiza with *Pinus*. 7. *Suillus*

L. Glandulae none.

M. Hymenophore arcuate-decurrent in young specimens shortly before full maturity, tubes rather short to barely medium long; spores small (5.5–11 x 2.7–4.8 μ); growing on pine trunks. 10. *Phlebopus*

M. Hymenophore arcuate-decurrent but in primordial stage; tubes medium to long in mature specimens; spores usually larger than indicated above; not or only accidentally growing on pine trunks. 11. *Pulveroboletus*

K. Pileus without yellow pulverulence in any stage; stipe neither beset with glandulae, nor viscid in any stage; hymenophore arcuate-decurrent but in primordial stage, tubes medium to long.

N. Pores wider than 1 mm. in diameter.

O. Pileus viscid and tomentose at the same time; carpophore small (pileus 10–20 mm.); spores small (6 -9.3 x 2.8 -4.2 μ); trama of the *Phylloporus*-type. 9. *Xerocomus*

O. Pileus rarely viscid and tomentose at the same time; carpophore mostly larger than 20 mm. broad; spores larger than 9.3 μ, or at least some of the spores of a print larger; trama of the *Phylloporus*-, or of the *Boletus*-type; fungi not combining the characters indicated above.

P. Surface of the pileus (if fresh and young) strongly reacting with NH_3 and NH_4OH, becoming vivid blue, to bright bluish green; trama of the *Phylloporus*-type. 9. *Xerocomus*

P. Surface of the pileus not reacting as indicated above; trama of the tubes of the *Boletus*-type.

Q. Pores vivid golden yellow, remaining so on drying; stipe not very thick, subglabrous and smooth; context unchanging; pileus viscid when wet. 11. *Pulveroboletus*

Q. Not combining the above characters. 12. *Boletus*

N. Pores decidedly smaller than 1 mm. (if in doubt, or if pores around 1 mm. wide, see "O"). 12. *Boletus*
(but compare *Pulveroboletus retipes*)

H. Spore print without an olivaceous tinge ("Isabella color," some kind of vinaceous pink to wood brown, fawn color, etc., or a rusty brownish yellow).

R. Spore print rusty brownish yellow; spores under the microscope bright and intensely golden yellow; context combining white (unchanging) color and mild taste; stipe combining smooth and glabrous surface; pileus not viscid, not scrobiculate. 13. *Xanthoconium*

R. Spore print not rusty brownish yellow, at least not when fresh; spores under the microscope brownish melleous, yellowish melleous, pale melleous or subhyaline to hyaline; context not combining white (unchanging) color and mild taste unless the pileus is viscid or scrobiculate; stipe not combining smooth and glabrous surface unless the pileus is viscid or scrobiculate.

S. Stipe with distinct or indistinct glandulae, usually cylindric and not very thick, rarely swollen; mycorrhiza with pines; spore print "ochraceous tawny" to "Isabella color"; hymenophore adnate-decurrent; pileus glutinous. 7. *Suillus*

S. Stipe always completely devoid of glandulae (lens), usually cylindric and then very thick, or thickened at some part; mycorrhiza with pines or with other trees, never exclusively with pines; spore print not "Isabella color" (the nearest it may occasionally come to "Isabella color" is "colonial buff"); pileus viscid or dry. 14. *Tylopilus*

Subfam. **Gyrodontoideae** Sing. subfam. nov.

Hyphis constanter fibuligeris; sporis ellipsoideis vel globosis, brunneolis vel flavis.

Characters of the subfamily: see key (p. 226) and Latin diagnosis. The type genus is *Gyrodon* Opat.

The genera *Gyrodon*, *Paragyrodon* (tribus Gyrodonteae Sing.) on one hand, and *Gyroporus* (tribus Leucoporelleae (Gilbert) Sing.) on the other hand did not seem to be easily combined into one subfamily or tribe, notwithstanding their obvious similarities, that is not until the tropical genus

Phaeogyroporus was discovered. The latter represents a perfect connecting link between the two former tribes Gyrodonteae and Leucoporelleae which now become superfluous.

1. **Gyroporus** Quél., Enchir., p. 161. 1886, *emend.* Pat., Ess. tax., p. 124. 1900.
   Suillus Karst., Bidr. Finl. Nat. Folk **37:**v. 1882, *non* S. F. Gray (1821).
   Coelopus Bat., Bolets, p. 12. 1908.
   Leucobolites G. Beck, Zeitschr. Pilzk. **2:**146. 1923.
   Leucoconius (Reichenb.) G. Beck, Zeitschr. Pilzk. **2:**146. 1923.

Characters of the genus: Pileus non-viscid, glabrous to coarsely fibrous-subsquamose; cuticle made up of repent or subascendant elongate but sometimes rather short and thick hyphae with thin or thick walls; hymenophore tubulose with concolorous, small to more often medium to large pores, depressed around the stipe, rather long, white, pink, or pallid-stramineous; spore print yellow; spores stramineous-subhyaline to yellow, ellipsoid, rarely more elongate than twice as long as broad, of medium size but rather variable in this regard; cystidia present; trama of the hymenophore-walls truly bilateral; stipe hollow or solid, its surface glabrous or fibrous, not reticulate; context white or whitish, unchanging, or becoming bright blue on exposure; hyphae (except for rare parthenogenetic aberrations) constantly with clamp connections; the usual inorganic reagents causing very slight or no color reactions; said to contain no boletol. Growing on the ground in temperate as well as in tropical regions, possibly occasionally forming mycorrhiza but sometimes fruiting without mycorrhizal connections. The type species is *Gyroporus cyanescens* (Bull. *ex* Fr.) Quél. This is also the type species of the genus *Leucoconius* Beck, and it is assumed that the logical type species of *Suillus* Karst. is the same species. The genus *Leucobolites* Beck is obviously framed around the characters of *Gyroporus castaneus*, the first species cited, and since this belongs in *Gyroporus*, all three genera are synonyms of *Gyroporus*. In the original sense of Quélet, *Gyroporus* contained several species which are now excluded from this genus, but Patouillard's emendation leaves no doubt about the sense in which *Gyroporus* has to be restricted. The genus *Gyroporus* has been almost unanimously accepted by mycologists at present though it usually is incorrectly (spore print "white") or insufficiently (no mention of clamps) characterized.

KEY TO THE SPECIES

A. Pileus white, whitish cream color, stramineous, greenish, clay color, pinkish or umber.
   B. Context unchanging on exposure.
      C. Pileus "tawny olive," "Isabella color," "Saccardo's umber" when fresh, strongly and coarsely fibrous and usually subsquamose, assuming a characteristic green color on drying if the specimens have been old, watersoaked and exposed for several hours before drying.
         2. G. umbrinisquamosus

C. Pileus not as dusky colored as above, more white to pale stramineous, or pinkish, less strongly fibrous to completely glabrous, not assuming a green color on drying. 1. *G. subalbellus*

B. Context strongly bluing on exposure. 3. *G. cyanescens*

A. Pileus fulvous, fulvous-ferruginous, castaneous-fulvous, tawny, cinnamon to whitish cinnamon, or deep red, purplish carmine, or deep purplish violet.

D. Pileus deep purplish violet. *G. atroviolaceus*

D. Pileus not colored as above.

E. Pileus deep red, purplish carmine. 4. *G. purpurinus*

E. Pileus not colored as above. 5. *G. castaneus*

1. **Gyroporus subalbellus** Murr., N. Am. Fl. **9**:134. 1910.
Suillus subalbellus Sacc. & Trott., Syll. **21**:252. 1912.
Gyroporus roseialbus Murr., Mycologia **30**:520. 1938.

Pileus with a basic white color but sometimes flushed with "sea shell pink," or "apricot buff," the disc often "cinnamon buff," and besides frequently with cinnamon or pale cinnamon dots, rarely pale yellow instead of white, frequently partly or entirely covered with a coarse but thin "colonial buff" fibrillosity reminiscent of *G. cyanescens* and then parts of the pileus or the entire surface shaded with this color, the disc, if fibrillose, even reaching "chamois," the glabrous surface sometimes minutely tessellate, not viscid, the margin sterile and then incurved when young, or fertile, convex, frequently with more or less depressed center, (25)–35–100 mm. — *Hymenophore* white or whitish, becoming "cream color" to "mustard yellow" with age, about 4 mm. deep, depressed or rarely adnate to the stipe, unchanging on injury; tubes rather long, (3)–5–8 mm. long; pores concolorous, rather small (2.5 per mm.) to medium wide (0.9 per mm.); spore print "colonial buff" with a hue of "straw yellow." — *Stipe* white or somewhat concolorous with the pileus, very frequently flushed with pink, "sea shell pink," "shell pink," "buff pink," "light salmon orange," frequently stained with "cinnamon buff" like the pileus, or with brownish, olivaceous or umbrinous spots near the base, the apex usually more white than the rest of the stipe, glabrous or somewhat furfuraceous to slightly tomentose-fibrillose, smooth, equal, or with enlarged base, rather frequently swollen and distorted, solid, becoming stuffed and finally with cavities or hollow, (25)–33–80 x (6)–11–30 mm. — *Context* white, sometimes salmoneous in the cortex of the stipe, absolutely unchanging; odor none, or agreeable, reminding one of cinnamon; taste mild.

Spores 7.5–13.8 x 4–5.5–(6) μ, short-cylindric-ellipsoid, ellipsoid, or ovoid, hyaline with a slight or bright yellowish tint, with suprahilar depression or applanation, smooth; *basidia* 28–33 x 8–11.5 μ, 4-spored; *cystidia* versiform, mostly fusoid; trama of the tube-walls truly bilateral as in *G. castaneus*; *fibrillosity of the pileus* and the stipe of strands of parallel hyphae, or of irregularly interwoven hyphae with often thick, yellowish walls, occasionally rather short members between septa, 3–18 μ thick, the terminal ones usually clavate, more rarely subulate and more or less acumi-

nate; all *hyphae* with clamp connections, or at least a large percentage of them with clamp connections, in some rare depauperate forms all hyphae clampless.

Chemical reactions: **KOH** negative (faintly sordid). — **NH_4OH** and **NH_3** negative. — **HNO_3** negative (faintly yellowish). — **$FeSO_4$** faintly grayish-pallid, stuffing of old stipes pale green (weak reaction). — **Methylparamidophenol** in the fibrillose form in Highlands County negative, in the glabrous form in Alachua County distinctly and quickly positive (deep violet). — **Phenol** very slowly becoming more or less deeply chocolate. — **Formol** negative or almost so (rarely very pale grayish red). — **Aniline** negative.

Habitat: Under oaks, and under pines in mixed and pure stands, on lime rock, gravel and sandy soil, outside the woods and in dense high, mesophytic and tropical hammocks, solitary, or more commonly in groups, fruiting from May to October.

Distribution: From North Carolina to Florida and west to Mississippi. In Florida common in all zones.

Material studied: **Fla.** Alachua Co., Gainesville, under oaks, August 1937, **type** of *G. roseialbus* (FLAS); also **co-type** and **authentic** material (FH), *F 9292* (FLAS); *F 19576* (FLAS); in and near Gainesville, *R. Singer, F 2560a* (FH); *F 2021* (FH); *F 2105* (FH); *F 2147* and *2147a* (FH); Sugarfoot Hammock, under oak, *R. Singer, F 2570* (FH); Newnan's Lake, Sept. 1941, under scrub oak, *G. Weber*, (det. Murrill) *F 18577* (this is a *forma depauperatus*) (FLAS); Highlands Co., Highlands Hammock State Park, sandy roadside under *Pinus palustris*, August 1942, *R. Singer, F 389* (FH); Marion Co. near Altoona, October 1941, *W. A. Murrill, F 21541* (FLAS); Dade Co., Matheson Hammock, *R. Singer, F 707* and *F 707 a* (FH); Brickell's Hammock, *R. Singer, F 1071* (FH).[6] — **Miss., type** of *G. subalbellus* (N.Y.)

Murrill says that his *G. roseialbus* differs from *G. subalbellus* "in its rosy tints, glabrous surface, and solid stipe." I did not find these characters correlated in any way. The type of *G. subalbellus* is partly fibrillose, but I have found more distinctly fibrillose specimens with pink stipe, and perfectly glabrous specimens without a suggestion of pink. The solid stipe later becomes hollow, a phenomenon that can be observed at varying stages of development exactly as in *G. castaneus*. My number *F 2570* has slightly furfuraceous pileus and is consequently intermediate between the glabrous and the fibrous form. Somebody may yet find it worth his while to erect formae for all these variations and combinations of unimportant characters. At present, I think we can do without them. The only character that gives some weight to the distinction between glabrous and fibrous forms is the reaction with methylparamidophenol; further tests will probably show that the reaction is variable in both forms.

[6] There is also an indication of this species from Seminole Co., Altamonte Springs (*fide* Beardslee).

Coker and Beers (Boletaceae, p. 14. 1943) mention a "*form with unchanging flesh*" of *G. cyanescens*. There is no doubt but that this is *G. subalbellus*.

Murrell's number *F 18577* is interesting because it represents an example of a depauperate (much smaller in all its parts), probably parthenogenetic form without clamp connections; the spores are normal, and the basidia 4-spored as usual. It belongs to the glabrous form. Murrill's co-types of *G. roseialbus* (*F 9887* and *F 9288*) are not cited here because they belong, at least partly, to *Xanthoconium stramineum*. The latter species and *G. subalbellus* are sometimes macroscopically similar but the shape of the spores, their color both under the microscope and in print, and, as a rule, the presence or absence of clamp connections help to identify them.

G. subalbellus, like other species of this genus, does not seem to show any preference for specific forest trees. I have found it growing exclusively under *Pinus australis* at one locality, under *Pinus palustris* at another, and many times under various species of *Quercus* without any conifers nearby.

2. **Gyroporus umbrinisquamosus** Murr., Bull. Torr. Bot. Club, **66**:33. 1939.

Pileus "tawny-olive," "Isabella color," "Saccardo's olive," strongly fibrous-tomentose-subsquamulose all over, more so on the margin, not viscid, convex, 55–75 mm. broad. — *Hymenophore* whitish becoming yellowish, deeply depressed around the stipe, tubes moderately long (about 6 mm.), pores concolorous, small (about 2.5 per mm.), spore print as in the preceding species. — *Stipe* concolorous with the pileus and covered with the same felt, more so toward the base, solid, soon becoming hollow, enlarged below, 50–85 x 12–25 mm. — *Context* white, unchanging; odor none, taste mild.

Spores 9.5–16 x 4.5–7.5 μ, ellipsoid to rarely somewhat allantoid, with a suprahilar applanation or depression, smooth, yellowish-hyaline; *basidia* 25–28 x 9–14 μ, 4-spored; *cystidia* 35–38 x 6.3–10 μ, numerous, especially near the pores, hyaline, more or less fusoid, the thickest part in the middle or nearer the apex which is rounded or acute; trama not studied; the *fibrous coating* of the pileus and the stipe consisting of strands of parallel, cylindric, greenish-melleous hyphae, with slightly thickened walls, the terminal members cylindric, fusoid, or clavate, 7–15 μ thick; *hyphae* with clamp connections.

Chemical reactions: Watersoaked, old material turns a characteristic green when dried slowly, this green color disappears later in the herbarium; reactives tested gave the same results as obtained with *G. subalbellus*.

Habitat: In turkey oak woods (*Quercus Catesbaea*) and in high hammocks (with *Quercus laurifolia* and *Q. virginiana*), on sandy, humous soil, fruiting from July until October. Solitary and rare.

Distribution: Known only from Alachua Co., Florida, U.S.A.

Material studied: **Fla.** Gainesville, Sept. 1938, **type** (FLAS); July 1943, *R. Singer, F 2776* (FH); West of Micanopy, Oct. 1939, *W. A. Murrill* (FLAS); Newnan's Lake, July 1943, *R. Singer, F 2911* (FH).

This species is very closely related to *G. subalbellus*, and though the

color change of dried specimens which I have never observed in the latter species, as well as possibly the higher upper limit of the spore measurements, would seem to favor its distinction as a separate species, I have hesitated a long time to admit it as such. One of W. A. Murrill's collections (*F 18461*) looks exactly like *G. umbrinisquamosus* in dried condition, and at the same time, the color of the pileus was indicated as pale yellow, and it was determined by Murrill as *G. roseialbus*. One may be inclined to consider this as a transitional form, yet it is possible that a line between this latter form and the typical *G. umbrinisquamosus* will prove to be constant enough to maintain the latter as an autonomous species.

3. **Gyroporus cyanescens** (Bull. *ex* Fr.) Quél., Enchir., p. 161. 1886.

Boletus cyanescens Bull. *ex* Fr., Syst. Mycol. **1**:395. 1821.
Leccinum constrictum (Pers. *ex*) S. F. Gray, Nat. Arr. Brit. Pl. **1**:647. 1821.
Boletus lacteus Lév., Ann. Sci. Nat. sér. III **9**:124, *pl. 9, fig. 1–2*. 1848.
Suillus cyanescens Poir. *in* Lam. *ex* Karst., Bidr. Finl. Nat. Folk **37**:1. 1882.
Gyroporus lacteus Quél., Enchir., p. 161. 1886.
Gyroporus cyanescens var. *lacteus* Quél., Fl. Mycol., p. 425. 1888.

Pileus stramineous-yellowish, subalutaceous, sordid or pale sulphureous, pale straw color, greenish yellow, or nearly whitish pallid, eventually often becoming a pale brownish umber, covered with a coarse fibrous felt, not viscid, pulvinate, usually becoming subplane or irregular, 35–120 mm. broad. — *Hymenophore* white, then yellowish, bluing on injury, depressed around the stipe, often almost free, tubes rather long (2.5–8 mm.), pores concolorous, irregularly polygonal or subcircular, moderately wide; spore print between "colonial buff" and "straw yellow." — *Stipe* cremeous-sordid, yellow, or otherwise similar to the pileus in color, paler (to white), or grayish white at the apex, rarely subglabrous, mostly covered with the same kind of felt as the pileus, smooth, solid or stuffed, then with several small cavities, or hollow, tapering upward, more rarely subequal, 30–120 x 10–30 mm. — *Context* of pileus white, strongly turning cyaneous (the blue of bachelor's buttons) when wounded, sometimes somewhat reddish brown in the base of the stipe and palest yellow–stramineous in the rest of the stipe, becoming greenish blue on injury; odor none; taste mild.

Spores 8–16 x 4–8 μ, ellipsoid to ovoid, most frequently 10–11 x 5–6 μ, smooth, stramineous-subhyaline; *basidia* 25–40 x 8.5–12 μ; *cystidia* 35–52 x 8–10.5 μ, cylindric-clavate, or cylindric-fusoid; *trama* truly bilateral; *fibrosity* of the pileus consisting of (5)–9–20–(25) μ thick, cylindric, stiff, yellowish hyphae, the thin ones lemon yellow, most septa with clamp connections.

Habitat: In woods and even on meadows of all kinds, most frequent on sandy soil and on sandy loam, also on clay soil; fruiting from July until November.

Distribution: Europe, Caucasus, North America. In Florida very rare, only in the northern part.

Material studied: **Fla.** Alachua Co., Gainesville, on the ground under pines, *W. A. Murrill* (FLAS). — **Canada,** N.B., July 1902, *W. G. Farlow*

(FH). — **N.H.,** White Mts., Crystal Cascade, on ground near stump, Sept. 1891, *W. G. Farlow* (FH); Chocorua, Aug. 1904, *W. G. Farlow* (FH). — **Mass.** Newton, Sept. 1892, *W. G. Farlow* (FH); Waverley, Aug. 1897, *W. G. Farlow* (FH); Magnolia 1907, *E. B. Blackford* (FH). — **N.Y.** Ebor, Nov., *C. H. Peck*, (as *Boletus variegatus*) (*217*) (NYS). — **Tenn.** Great Smoky Mts., Chimney Trail, birch woods, Aug. 1939, *D. H. Linder* (det. Snell) (FH); Greenbrier, *A. J. Sharp* (det. L. R. Hesler) (FH). — Numerous fresh collections and specimens in European herbaria. — **Caucasus,** Abkhazia, Saken R., under roots of *Fagus orientalis* Aug. 1929, *R. Singer* (W); Malaya Laba R., Aug. 1935, *L. N. Vasilieva* (KAZ).

This species cannot be distinguished with certainty from the two preceding species unless studied in fresh condition. I have to rely on W. A. Murrill's determination of the fresh material as far as the occurrence of this species in Florida is concerned. *G. cyanescens* is edible. It does not seem regularly to form mycorrhiza, at least no preference of any forest tree is shown, and sometimes fruiting bodies are formed far from any tree at all. The above description has been filed from notes on European and Caucasian collections of this author, except for the characterization of the trama which resulted from New England material, and strongly disagrees with the findings of Elrod and Blanchard who found it decidedly not bilateral. I can only repeat that it is essential to study young stages, just when the hymenium begins to sporulate, in order to be sure that comparable material of the species examined is at hand. If this is done, there is not the slightest difference in the structure of the trama of the various species of *Gyroporus*.

4. **Gyroporus purpurinus** (Snell) Sing. comb. nov.

Boletus castaneus f. purpurinus Snell, Mycologia **28**(5):465. 1936.

PLATE I, FIG. 1–4.

Pileus "neutral red," "mineral red," almost "bordeaux," or "garnet brown" and "maroon," or "deep vinaceous," velutinous or punctate-subtomentose, then somewhat furfuraceous, pulvinate-convex, then plano-convex, often with more or less depressed center, with obtuse margin, not viscid, 11–50 mm. broad. — *Hymenophore* white, eventually becoming "naphthalene yellow," adnate-subdepressed, becoming deeply depressed around the stipe, convex beneath, pores small, then wide (1 to 3 per mm.), concolorous; spore print between "amber yellow" and "citron yellow," *i.e.* brighter yellow than in the *G. cyanescens* group. — *Stipe* concolorous with the pileus and occasionally slightly inclining to brownish, apex frequently white, entirely velutinous-subfurfuraceous, stuffed and with cavities, or plainly hollow, equal or tapering upward, 30–40 x 2.5–8 mm. — *Context* pure white, unchanging; odor none; taste mild.

Spores 8.2–11.5 x 5.5–6.8 μ; *basidia* 21–27 x 11.5–12.2 μ, 4-spored; *cystidia* at the pore mouths characteristically narrowly subulate, the apex acuminate-obtusate or subacute, hyaline, thin-walled, numerous, 23–43 x 3.3–4.7 μ; *trama* of the tube walls truly bilateral, the mediostratum scarcely

hyaline; *cuticle* consisting of irregularly arranged, unequal hyphae, the terminal members of which are mostly erect to form (with 1–2 of their basal hyphae) a trichodermium-palisade, the terminal members cystidioid, subulate, ampullaceous or fusoid, rarely vesiculose, 40–100 x 5.3–20 μ, thin- or moderately thick-walled, filled with a purple cell-sap; a similar covering on the stipe; *hyphae* with clamp-connections, but the clamps may be rather scattered.

Chemical reactions: **NH_3, NH_4OH, KOH** and **aniline-oil** on cuticle and on context almost negative.

Habitat: Shaded places under various trees, in tropical and low hammocks, and also in forest of a more northern type outside of Florida, in general growing under the same conditions as *G. castaneus*, but never as far from forest trees as the latter. Solitary to gregarious, fruiting from July until October.

Distribution: North America from New York to Florida, and west to Michigan. In Florida widely distributed, moderately frequent in all zones.

Material studied: **Fla.** Dade Co. Matheson Hammock, Sept.–Oct. 1942, under *Bursera, Ficus, Nectandra, Quercus, R. Singer, F 878, F 1174* (FH); Oct. 1942, under *Pinus caribaea, Casuarina spec., Quercus virginiana, R. Singer, F 1174 a* (FH); Alachua Co., Gainesville, July 1943, under *Liquidambar, Ostrya, Carpinus, Prunus, Quercus* spec., *R. Singer, F 2623* (FH); Planera Hammock, July 1943, *R. Singer, F 2885* (FH); July 1938, *W. A. Murrill & Erdman West, F 7917* (FLAS).

G. purpurinus is, in the author's opinion, not a form or variety of *G. castaneus* but a good species. Aside from the constant and persistent difference in color, this species is of slightly smaller average size than *G. castaneus*, and its surfaces have a much more pronounced tendency to become furfuraceous than in the latter species. This is by no means a color variant within the ordinary variation of *G. castaneus* since it is absent in parts of the north and west of the United States and in Europe, and it is also not a geographic race because it grows together with *G. castaneus* in some states of this country. This most beautiful species of the Gyrodontoideae has first been validly described by W. H. Snell but it has also been collected by W. A. Murrill who filed it under an unpublished varietal name.

5. **Gyroporus castaneus** (Bull. *ex* Fr.) Quél., Enchir., p. 161. 1886.

Boletus castaneus Bull. *ex* Fr., Syst. Mycol. **1**:392. 1821.
Boletus cyanescens B *fulvidus* Fr., Syst. Mycol. **1**:395. 1821.
Boletus fulvidus Fr. *ex* Fr., Epicr., p. 426. 1838.
Boletus testaceus Pers., Mycol. Eur., **2**:137. 1825.
Suillus castaneus Poir. *in* Lam. *ex* Karst., Bidr. Finl. Nat. Folk **37**:1. 1882.
Gyroporus castaneus var. *fulvidus* Quél., Enchir., p. 161. 1886.
Boletus rufocastaneus Ell. & Ev., N. Am. Fungi, 2nd ser., no. 2302. 1890, *nomen nudum.*

Pileus "cinnamon rufous" to "Kaiser brown," or "tawny" to "hazel," or "Sanford's brown" to "xanthine orange," or "pecan brown" to "Rood's brown," rarely paler ("cinnamon buff," "pinkish buff," or even "pale pink-

ish buff"), usually lighter colored on the margin, pubescent-subvelutinous to finely tomentose, rarely subglabrous, not viscid, convex, then irregularly applanate, or with depressed center, or rarely entirely concave, (20)–30–80 mm. broad. — *Hymenophore* white or whitish at first, then becoming cream color to light yellow or light lemon yellow from the spores, sometimes staining brown on injury, depressed around the stipe, or becoming so, tubes up to 8 mm. long; pores small to medium (1–3 per mm.); spore print as in *G. purpurinus*. — *Stipe* concolorous with the pileus, the apex usually paler, slightly tomentose-subvelutinous, not viscid, sometimes irregularly furrowed, tapering upward, more rarely subcylindric, solid, then stuffed, and eventually hollow, the hollow stage beginning at different stages depending on the individual, rarely stuffed even when quite old, 35–80 x 8–22 mm. — *Context* white or whitish and unchanging on exposure, the cortical layer of the stipe and sometimes under the cuticle of the stipe concolorous with the surface, firm and fleshy, later soft and brittle; odor none; taste mild.

Spores 7–11 x 4.5–6 μ, ellipsoid with suprahilar applanation, stramineous-hyaline to stramineous, smooth, many of them with an ellipsoid to subglobose central oil-drop, with thin to rather thick, simple wall, non-amyloid; *basidia* 27–40 x 8–11.2 μ, 4-spored; *cystidia* on the pore mouths subulate, gradually tapering from the 4–6 μ thick base toward the acuminate but rarely acute apex, 20–55 μ long, thin-walled, hyaline, numerous; on the side of the tube walls the cystidia are scattered, more or less fusoid, 38–46 x 7–11 μ; *cuticle* of the pileus and the stipe consisting of rows of filamentous hyphae which are rarely shortened and irregularly vesiculose, their diameter 5–17.5 μ, their septa with clamp connections (some clampless), with rather thick wall, with fulvous, yellow, or hyaline cell-sap, terminal hyphae often upright with rounded apex; *trama* of the hymenophore truly bilateral with distinctly divergent, looser lateral stratum in young specimens; the majority of the thin-walled hyphae with clamp connections.

Chemical reactions: **KOH** and **NH_4OH** very slight or no reaction; **methylparamidophenol** positive on context of very fresh material, reaching "vinaceous-purple," in less fresh material merely staining brown; **phenol** chocolate.

Habitat: In mixed forests, coniferous woods, frondose woods, open places, low hammocks, mesophytic hammocks, and high hammocks, on lawns under oaks, on fields and pastures, on various kinds of soil, however rare or wanting on strongly calcareous soil, very rarely on very decayed wood, fruiting from May till October.

Distribution: With certainty known from Europe and North Africa, and, what appears to be the same species, in temperate North America, common in both dry-warm and damp-warm climates, also indicated in Australia but unconfirmed from there; in Florida common but not reaching the tropical zone.

Material studied: **Fla.** Alachua Co. Gainesville, det. W. A. Murrill (FLAS); *R. Singer, F 2754* (FH); *F 2145* (FH); *F 2145a* (FH); Highlands Co., Highlands Hammock State Park, *R. Singer, F 51, F 51 a, F 51 b*

(FH). — **N.H.** Shelburne, *W. G. Farlow* (FH). — **Mass.:** Bedford, *W. G. Farlow* (FH); Cambridge, *W. G. Farlow* (FH); *R. Singer* (FH); *G. D. Darker* (FH); Jamaica Plain, *G. D. Darker, 5223* (FH); *6141* (FH); *6153* (FH); Wellesley, *D. H. Linder* (FH); Newton, *W. G. Farlow* (FH); *G. D. Darker, 5364* (FH); Canton, July 1933, *D. H. Linder* (FH); Aug. 1933, *id.* (FH); Purgatory swamp, *D. H. Linder & R. Singer* (FH); Wakefield, *D. H. Linder & R. Singer* (FH); Nantucket Co., *E. V. Seeler, 108* (FH). — **N.J.** Newfield, 1886, *Ellis*, Herb. Farlow *ex* Herb. Ellis (*B. rufocastaneus* Ell., **authentic**) (FH); 1891 (FH); Ellis and Everhart, N. Am. Fungi, l.c. (**type** of *B. rufocastaneus*) (FH). — **Spain,** Catalonia, Aiguamoix Valley, Aug. 28, 1934, *R. Singer* (BA), and numerous collections of fresh material from France to the Caucasus; also abundant material in various herbaria.

EXTRALIMITAL SPECIES

Gyroporus atroviolaceus (Hoehn.) Gilbert, Bolets, p. 102. 1931.

Suillus atroviolaceus Hoehn., Sitz.-ber. Akad. Wiss. Wien **123:**87; Fragm. 16 (834):39. 1914.

This species has been described from Java. The type (FH) shows ellipsoid hyaline-citrinous spores with a slight suprahilar depression, or applanation, 8.8–9.5 x 6.3–6.7 μ; basidia 26.5–31.5 x 12–14 μ, 4-spored; cystidia fusoid, brownish, 41–75 x 7–16 μ; cuticle consisting of elongate hyphae with cylindric, clavate, or broadly fusoid terminal members, the apices of which are frequently thickened, 25–90 x 9.5–21 μ, many septa with clamp connections; they are now brown, but Hoehnel, on fresher material, found them violet, and up to 140 x 25 μ.

SPECIES INCOMPLETELY KNOWN

Gyroporus Earlei Murr., Mycologia **13:**60. 1921.

Boletus Earlei Overh. *in* Seaver & Chardon, Sci. Surv. Porto Rico **8:**156. 1926.

This species, described from the West Indies, is preserved but not in a condition that would permit any conclusions.

Gyroporus caespitosus Clel., Toadst. & Mushr. **2:**186. 1935.

This species, described from South Australia, cannot be considered as certainly belonging in this genus as long as no specimens are available.

SPECIES EXCLUDENDAE

Gyroporus rufus (Schaeff. *ex*) Quél. belongs in *Leccinum*.

Gyroporus scaber (Bull. *ex* Fr.) Quél. belongs in *Leccinum*.

Gyroporus porphyrosporus (Fr.) Quél. is *Porphyrellus pseudoscaber* (Secr.) Sing.

Gyroporus asprellus (Fr.) Quél. is a doubtful species, hardly a *Gyroporus*.

Gyroporus deflexus Murr. (*Leucogyroporus deflexus* Snell) is a young stage of some bolete but most certainly not a *Gyroporus*.

Gyroporus praeanisatus Murr. belongs in *Tylopilus*.
Gyroporus pisciodorus Murr. is *Tylopilus tabacinus* (Peck) Sing.
Gyroporus fumosiceps Murr. is *Boletus fumosiceps* Murr.
Gyroporus Rhoadsiae Murr. is *Tylopilus Rhoadsiae* (Murr.) Sing.
Gyroporus stramineus Murr. is *Xanthoconium stramineum* (Murr.) Sing.

Gyroporus jamaicensis Murr. (*Suillus jamaicensis* Sacc. & Trott.)

This species, described from the West Indies, shows some interesting characters. The spores of the type (NY) are ellipsoid, smooth, non-amyloid, about twice as long as broad, with suprahilar depression or applanation, thin-walled, subhyaline, with hyaline walls and faintly yellowish contents, asymmetric, 9.5–11 x (4)–4.8–5.2 μ; basidia 20–25 x 10–12 μ; there are some hyaline cystidia with swollen base and ampullaceous apical neck, 20–30 x 11–12 μ, the neck *e.g.* 10 x 2.5–3 μ; trama of the hymenophore decidedly truly bilateral with a melleous, denser, more parallel-subinterwoven axillar mediostratum and a loosely arranged, strongly gelatinized hyaline lateral stratum with distinctly divergent hyphae; all septa are clampless; cuticle of the pileus consisting of hyphae which are little more than 1 μ thick but toward the surface become broadened up to 12 μ in diameter, and clavate; some clavate bodies of 6–8 μ diameter were observed at the apex of the stipe. As long as nothing is known about the variabilities of the characters and the exact color of the spore print and the chemical reactions, I hesitate to transfer this species to any other genus. However, it is obvious that this is not a *Gyroporus*, and my guess is that it belongs in *Tylopilus*.

Gyroporus albisulphureus Murr., Lloydia **7**:325. 1944.

I have seen only a small fragment of this species, and cannot say what it is. If it is not an abnormally colored form of some known species, it will probably be sought for among *Pulveroboletus* (if viscid) or *Boletus* where it would stand out because of its milk-white pileus. The microscopical characters which I could ascertain did not bear out the opinion of Murrill, who links it with *Gyroporus*. The spores are too elongate, not right in color, and the hyphae are without clamp connections.

Gyroporus bisporus Murr., l.c.

A small fragment of this species (FH), kindly sent me by its author, is insufficient to dispose of it. However, it can be said with certainty that it is not a *Gyroporus*.

2. **Phaeogyroporus** Sing., Mycologia **36:**360. 1944.

Characters of the genus: see key, p. 226, and the original description, *l.c.* The type species is *Phaeogyroporus Braunii* (Bres.) Sing. There are no representatives of this genus known to occur in Florida. However, in view of the taxonomic importance of this genus, and the possibility that at least one of its species may yet be discovered in the state, we add the descriptions of two extralimital species.

Phaeogyroporus Braunii (Bres.) Sing., Mycologia **36:**360. 1944.

Boletus Braunii Bres., Bull. Soc. Myc. Fr. **6:** XXXVII. 1890.
Suillus Braunii Kuntze, Rev. Gen. Plant. 3^2:535. 1898.

Pileus olive becoming dirty brown, smooth, glabrous, convex, becoming partly concave, 80–150 mm. broad. — *Hymenophore* yellow, turning brown, attenuate-adnexed or emarginate-depressed around the tubes, applanate beneath, but concave near the margin, not decurrent except in youth, tubes 8–11 mm. long, pores small (about 2 to a mm.); spore print olive brown. — *Stipe* yellow turning dirty brown, subglabrous, smooth, solid, tapering upward or downward, or thinnest in the middle, 55–63–(100, according to Bresadola) x 20–42 mm.; mycelium dingy melleous. — *Context* cream color in both pileus and stipe, moderately juicy, firm in the stipe; odor and taste not recorded, probably not distinctive.

Spores 7–8 x 5.3–6.3 μ, mostly 8 x 6 μ, smooth, pale brown, ellipsoid; *basidia* 21–25 x 9–9.5 μ; *cystidia* 40–50 x 6–18.5 μ, vesiculose, claviform, or subfusoid; *trama* of the hymenophore consisting of 3.5–9 μ thick, often somewhat wavy-subinterwoven (in mature material) hyphae, and some laticiferous vessels of about 4 μ diameter; *hyphae of the cuticle* of the pileus somewhat interwoven, with up to 7.7 μ thick terminal hyphae which are clavate, hyaline, and usually thick-walled (about 1 μ thick), with numerous large clamp connections.

Habitat: Solitary on the ground, fruiting during the early rains.

Distribution: Tropical West Africa, Camerouns to Liberia.

Material studied: **Liberia,** Ganta, April 1939, *G. W. Harley* (det. Singer) *40* (FH).

I have not seen the type collection. However, the few insignificant discrepancies between Bresadola's description and our own, which is entirely drawn from Liberian material, do not seem to indicate that there is a chance of a mistake. The spores are considerably smaller in Bresadola's diagnosis but young spores in our specimens are 5 x 4 μ. The smaller size of Bresadola's specimens and the shorter, subdecurrent tubes clearly indicate that the type was a rather young specimen, probably immature. Therefore Bresadola did not find basidia. What he thought were basidia, are probably cystidia according to the measurements given. *Boletus sudanicus* Har. & Pat. seems to be close to this species, possibly identical; cf. Heim, R. Rev. de Mycol. **1:**13. 1936.

Phaeogyroporus tropicus (Rick *apud* Rehm & Rick) Sing., Mycologia **36:**360. 1944.

Boletus tropicus Rick *apud* Rehm & Rick, Broteria **5:**223. 1905.

Pileus yellowish brown, velutinous to minutely subtomentose-squamulose, sometimes areolate, usually smooth, semiglobose, later depressed in the center and more or less wavy at the margin, 30–100 mm. broad. — *Hymenophore* ochraceous, then with an olivaceous tinge, the lower surface not or not much concave under the margin of the pileus, the rest applanate to convex and deeply emarginate around the stipe. — *Stipe* brownish yellow,

smooth, glabrous, solid, cylindric, or tapering downwards or upwards, 25–40 x 8–24 mm. — *Context* whitish; taste and odor not recorded.

Spores (6.3)–6.8–9.5–(11) x (4.9)–5.3–6.8 μ, short-ellipsoid, smooth, light brown, without suprahilar depression; *basidia* 9.3 μ broad, 4-spored; *cystidia* not seen but probably present; *cuticular tomentum* consisting of rich-melleous to golden-melleous, unequal or cylindrical, filamentous, often waved and nodose hyphae which often look like laticiferous vessels, 2.8–12 μ in diameter, scarcely intermixed with much thinner and less opaque hyphae; most of the *septa* with clamp connections.

Habitat: On the ground, the mycelium forming mycorrhiza with trees.

Distribution: Brazil, south to Argentina, also in Liberia, Africa.

Material studied: **Brazil** 1906, *J. Rick, 31* (*Boletus crassus* but recognized as **authentic** material of *Boletus tropicus* by Rick *in litt.*) (FH). — **Liberia,** Ganta, *G. W. Harley* (FH).

The above materials are identical with each other. *P. tropicus* differs from *P. Braunii* in being somewhat smaller on an average (though large specimens of the former may be as large or larger than small specimens of the latter) and also in the shape of the hymenophore and the size of the pores. *P. tropicus* may yet turn up in the lists of Central American or even Floridan collectors. *P. Braunii* is more accurately known at the time being, but the congenerity and the specific autonomy of both these species cannot be doubted.

P. tropicus has been shown to form a mycelium-crust closely connected with the roots of *Citrus* spp. in Brazil covering the colonies of *Pseudococcus Comstocki* which attack the roots of these citrus after they have been carried there by an ant (*Solenopsis saevissima* var. *moelleri* Forel); these mycelial crusts of the *Phaeogyroporus* are called *criptas* by the Brazilian writers. The *Pseudococcus* living in symbiosis with the fungus is thought to be the immediate reason for the subsequent dying of the trees affected, though the action of an endophytic mycorrhizal fungus weakens the plants sufficiently prior to becoming subject to a fatal attack by the complex of fungus and *Pseudococcus*. This extremely complicated and interesting coöperation of symbiosis, epibiosis and parasitism has been described and illustrated, discussed and compared with an analogous case in Africa, *viz.* the phthiriosis of the coffee tree in Cameroun, by C. R. Gonçalves (Observações sobre Pseudococcus Comstocki (Kuw. 1902) atacando Citrus na Baixada Fluminense. Rodriguesia **4**:179–198. *fig. 1–39*. 1940) and F. R. Milanez (Observações sobre uma estranha doença das laranjeiras. Rodriguesia **4**:199–263, *pl. 1–18*. 1940). Since we have been able to state that *P. tropicus* occurs in Liberia, it would be interesting to find out whether or not it has anything to do with phthiriosis in Cameroun, or what precisely its biological rôle in Africa is.

3. **Paragyrodon** (Sing.) Sing., Ann. Mycol. **40**:25. 1942.
Gyrodon subg. Paragyrodon Sing., Rev. de Mycol. **5**:7. 1940.
Characters of the genus: see key, p. 226. Type species *P. sphaerosporus*

(Peck) Sing. (*Boletus sphaerosporus* Peck). *Paragyrodon* is not represented in the flora of Florida.

4. **Gyrodon** Opat., Comm. Hist.-Nat. Fam. Fung. Bolet., Wiegmann's Arch. **2**(1):5. 1836.

Uloporus Quél., Enchir., p. 162. 1886 (proposed lecto-type *U. lividus*)

Boletinellus Murr., Mycologia **1**:9. 1909 (type *B. merulioides*)

Characters of the genus: Pileus not quite glabrous and inclining to become viscid in wet weather; hymenophore of irregularly arranged (gyrose) or boletinoid, or almost lamellate tubes or honey-combs, arcuate-decurrent; spore print brown or olive brown; stipe not reticulate, not hollow, not glandulose, avelate; context either changing color or unchanging on exposure; spores short-ellipsoid to subglobose, more rarely subcylindric-subreniform (but very short), smooth, brownish; cystidia not differentiated excepting cheilocystidia which are rather inconspicuous; hyphae with clamp connections. Habitat on wood or on the ground, and in the latter case often forming mycorrhiza with *Alnus*, *Fraxinus*. The genus is almost cosmopolitan. Of the six or seven species known, one occurs in Florida.

The type species of *Gyrodon* is *G. sistotremoides* (Fr.) Opat., a synonym of *Boletus sistotrema* Fr., Syst. Mycol. **1**:389. 1821, which would appear to be the legal name of the plant. It has been argued (Kallenbach, Pilze Mitteleuropas **1**(15):113. 1935) that since Opatowski leaves *Boletus lividus*, the well-known European species of *Gyrodon* in the genus *Boletus*, and does not know *Gyrodon sistotremoides* himself, this latter may not be congeneric with *G. lividus*, and may rather be a rare deformation of some species with other affinities. It seems indeed that Karsten's *G. sistotrema* is nothing but *Suillus bovinus* since he indicates the spores as elongate. Despite the fact that Fries cites this description of Karsten's in his *Hymenomycetes Europaei*, this does not necessarily mean that Fries' species is likewise a *Suillus*. In fact, Fries cites at the same time "*B. brachyporus* Rostk." as synonym, and this figure in Sturm's Flora is considered to be a genuine *Gyroporus lividus* (see Gilbert, Bolets, p. 216. 1931). Konrad and Maublanc and other authors think that *G. sistotrema* and *G. sistotremoides* are synonyms of *G. lividus*, and judging from the description which is the only document we have, we admit that there is no good reason for eliminating this species from *Gyrodon* since it may well pass as an extreme form, *G. lividus*. It would thus become a form with more elongated stipe and "whitish" context, and the configuration of the hymenophore described by Fries would find its logical explanation when considered to be of the type observed in old stages of *Gyrodon lividus* rather than by looking for rare deformations in other genera. The secret of *Gyrodon sistotrema* will never be lifted in an absolutely conclusive way, and, as it seems to us, it would be best to let it go at that, and not cause nomenclatoral trouble by refusing "endorsement" of this species as a *Gyrodon sensu stricto*. The

general consensus appears to be rather to model *Gyrodon* along the characters of *Gyrodon lividus* even at the risk of having to conserve the generic name *Gyrodon* in this sense.

KEY TO THE SPECIES

A. Spores medium to large (6)–6.8–11 x 4.7–9 μ; pores wide, later becoming very wide, boletinoid or forming a hymenophore similar to that of *Phylloporus rhodoxanthus*. The American forms not combining bluing context with russet-staining stipe. Not connected with *Alnus*.

B. Pileus "russet"; hymenophore nearly of the *Phylloporus rhodoxanthus* type *G. intermedius*

B. Pileus olivaceous, sepia, or tan-clay-color, not reddish; hymenophore more or less boletinoid.

C. Context and tubes not bluing on injury. 6. *G. proximus*

C. Context and tubes bluing on injury.

D. Stipe usually slightly eccentric to central; carpophores growing neither on fern-trunks, nor in association with *Fraxinus americana*. South American species. *G. Rompelii*

D. Stipe usually strongly eccentric or lateral; carpophores growing either on fern trunks, or in association with *Fraxinus americana*. North America and Asia.

E. Carpophores rather robust, stipe comparatively thick; growing on very decayed wood or on earth in (probably mycorrhizal) association with *Fraxinus americana*. North American species. *G. merulioides*

E. Carpophores thin and small; stipe slender, growing on fern trunks. Javanese species. *G. spec.*

A. Spores small: 4–8 x 3–5 μ; pores rather small but elongate, later becoming irregularly elongate, of varying level, and therefore appearing as if toothed; context strongly bluing; stipe becoming russet-spotted, always associated (probably by mycorrhiza) with *Alnus nigra*, *A. viridis*, *A. incana*. *G. lividus*

6. **Gyrodon proximus** Sing. spec. nov.

Pileo obscure fusco, dein biso vel umbrino, saepe pallescente usque ad alutaceum, tomentoso in centro, subviscido, margine incurvo, dein attenuato, convexo, denique irregulariter applanato, 20–115 mm. lato. Hymenophoro submerulioideo, dein boletinoideo, poris tubulis concoloribus, immutabilibus, inaequalibus, flavis, subviridulis in vetustis; sporis 7–9.5–(9.8) x 4.8–6.2–(6.8) μ, melleo-brunneis; hyphis fibuligeris. Stipite pileo concolori, ut minimum ad basin, gradatim vel subabrupte hymenophoro apicem versus concolori, solido, subglabro, sublevi, 20–63 x 9–15 mm. Carne superficiebus pallidiore, plus minusve alutacea, aeri exposita immutabili; odore subtili vel nullo. Habitatio: Ad terram et ad ligna in silvis humidis Americae subtropicalis tropicalisque.

Pileus initially deep brown ("mummy brown") becoming "bister" or "Saccardo's umber," or "buckthorn brown," in many specimens bleaching to alutaceous ("pinkish buff," "cinnamon buff") or argillaceous ("clay color"), frequently with still paler portions ("cartridge buff"), tomentose, especially in the center, and often shining because of a tendency toward viscidity during heavy rains, with the margin incurved when young, later progressively thinning out and narrowly sterile in most specimens, convex, eventually irregularly flattened, 20–115 mm. broad. — *Hymenophore* "am-

ber yellow" to "wax yellow," or "aniline yellow," assuming a greenish tinge when old, deeply decurrent, tubes rather short, pores concolorous, unchanging, submerulioid, becoming more boletinoid, 0.5–1.3 mm. wide, on unequal level; spore print olive brown. — *Stipe* concolorous with the pileus, in the lower part, or at least at the base, gradually or somewhat abruptly paler and yellower toward the apex, usually reaching the color of the hymenophore just below the pores, both the stipe and the spores, or either of them exuding a chestnut colored watery liquid in some specimens, straight, or curved, eccentric to central, more rarely lateral, solid, 20–63 x 9–15 mm. — *Context* paler than the surface, more or less alutaceous, not changing on injury; odor slight, agreeable, or none.

Spores 7–9.5–(9.8) x 4.8–6.2–(6.8) μ, short-ellipsoid, smooth, honey-brown, occasionally subreniform, with rather thin or medium thick walls, with a short-ellipsoid central oil-drop, or without it; *basidia* 21–43 x 9–9.5 μ, 4-spored; *cystidia* on the pore-mouths (cheilocystidia) fusoid, bottle-shaped, or subulate, 15–17 x 4 μ, neck, if present, 2 μ in diameter; *trama* of the hymenophore truly bilateral, mediostratum slightly denser than the diverging lateral strata; *hyphae* with clamp connections.

Chemical reactions: **KOH** on surface of pileus, deep chestnut, or brown, usually fading to ochraceous but with a dark ring; on context brown. — **NH_3** on surface of pileus, lilac to deep brownish lilac. — **NH_4OH** on surface of pileus, deep chestnut or blackish to lilaceous, with a brownish-lilaceous or lilac ring around the wetted spot; on the context and on the tubes, blue. — **HNO_3** everywhere light reddish brown, reddish brown. — **H_2SO_4** on surface of pileus, deep chestnut; on context, ochraceous brown, or negative; on tubes orange brown. — **Formol** on context, greenish or bluish. — **$FeSO_4$** on tubes, green to blue-green.

Habitat: In moist lime sink hammocks and near creeks in swampy or low hammock vegetation, also said to occur in high hammocks and oak woods, on decaying wood and on the ground, fruiting from February (British Guiana) and June (Florida) to September.

Distribution: Known to occur in north Florida and British Guiana, probably also on Jamaica, apparently all over the Caribbean area.

Material studied: **Fla.** Alachua Co., Gainesville, *R. Singer, F 2649* (FH); *W. A. Murrill, F 18174* (FLAS); Devil's Millhopper, *R. Singer, F 2425* (**type**), *F 2425 a* (FH). — **British Guiana,** Plantation Vryheid, *D. H. Linder, 1005* (FH).[7]

This species differs from *G. merulioides* in having unchanging flesh and tubes, being somewhat more variable in its habit (even more often subcentrally stipitate than lateral), and showing somewhat different chemical reactions. It also differs slightly in the shades and distribution of the colors but this character is not quite reliable. In flat frondose woods, on the ground, it usually assumes the habit of *G. Rompelii* (from which it differs

[7] Specimens from Jamaica without notes cannot be listed as more than probably belonging here: Blue Mts., Morca's Gap, Sept. 21–24, 1908, *E. G. Britton* (det. W. A. Murrill) (as *Boletinus porosus ?*) (NY).

in having unchanging context and hymenophore) whereas, on steep landsides, banks, vertical surfaces of logs, etc., it tends rather to assume the general appearance of *G. merulioides*. The spores are definitely different from these of *G. merulioides* and *G. Rompelii* as well. However, the measurements and the indication of the shape would not clearly express the difference. The spores of all *Gyrodon* are variable in their proportions (Q = length : breadth), but in the bluing American species (*G. merulioides*, *G. Rompelii*), the spores with Q = 1.35 and less are more numerous than in the unchanging species (*G. proximus*) where the spores with Q = 1.45–1.60 are very common. Besides, the bluing species of this continent have spores which frequently, though not always, reach larger figures in length and especially in breadth, than *G. proximus*.

It is not clear what trees this species prefers, if any, and whether or not there is a mycorrhizal relationship between forest trees and the mycelium. There was in my original notes no comment made on a possible association with *Fraxinus*. The type locality has been made the subject of a second floristic analysis,[8] and the species of trees recorded then were: *Liquidambar styraciflua* (the decaying wood on which some of the specimens grew was likewise identified as belonging to sweet gum), *Ostrya virginiana*, *Carpinus caroliniana*, *Quercus virginiana*, also *Evonymus* and *Toxicodendron* were present. *Ulmus alata*, *Magnolia grandifolia*, *Tilia heterophylla*, *Fraxinus americana*, *F. pauciflora* were found farther away. Judging from the experiences with *Gyrodon merulioides* in the northern states, one would be inclined to think that *Fraxinus* is, here too, the mycorrhiza-tree of the *Gyrodon*. But, on the other hand, *Fraxinus* was definitely absent at least from one place where the *Gyrodon* was collected. Aside from this, *Fraxinus* does not occur in British Guiana, and is also not known on Jamaica. Since the specimens from British Guiana can hardly be anything but *G. proximus*, the association with *Fraxinus*, if ever existent farther north, must be flexible enough to allow replacement of this tree by some other species of the *Oleaceae*, or else the occurrence of the fungus is not necessarily restricted to the simultaneous presence of a mycorrhizal symbiont. In this regard, *G. proximus* seems to differ from *G. merulioides*.

EXTRALIMITAL SPECIES

Gyrodon intermedius (Pat.) Sing., Rev. de Mycol. **3**:172. 1938.

Phylloporus intermedius Pat., Bull. Soc. Myc. Fr. **11**:86. 1895.
Suillus intermedius Kuntze, Rev. Gen. Plant. **3**²:535. 1898.
Boletus intermedius Sacc., Syll. **14**:165. 1899.
Boletinellus intermedius Gilbert, Bolets, p. 105. 1931.

The type (FH) from Madagascar has the spores 7.8–9.2 x 5–6.8 μ, and

[8] A floristic paper (Lillian E. Arnold. A Field Trip to the Devil's Millhopper. Jour. E. Mitch. Sci. Soc. **52**(1):77–90. *pl. 7–10*. 1936) dealing with this lime sink vegetation was of great help. The author divides the sink-slopes in four zones. In the higher two zones where my number *F 2425 a* (co-type) was collected, *Fraxinus* has not been indicated.

the hyphae with clamp connections. No mention of the bluing of the context is made in the description. We also have West African material (Liberia, Firestone # 3, July 25, 1926, *D. H. Linder* (det. R. Singer) (FH) that belongs to this species because of the color of the pileus and the shape of the hymenophore, but the spores are slightly smaller (6–9.3 x 4.7–5.5 μ, mostly 6.8–7.8 x 4.8–5 μ); basidia 26–28 x 7.5–11 μ; hyphae with clamp connections. The specimens show larger and more central stipes like *G. Rompelii*, and the flesh turns blue on injury (when fresh) as in the latter. The pileus is "russet" and the hymenophore "lemon chrome" in fresh condition. For the time being, we do not think it wise to separate these forms specifically.

Gyrodon Rompelii (Pat. & Rick) Sing., Rev. de Mycol. **3**:172. 1938.
Phylloporus Rompelii Pat. & Rick, Broteria **6**:81. 1907.

The type and authentic material (FH) has spores exactly as *G. merulioides*, (7.5–10.5 x 6–7.5 μ), and the authors indicate that the fresh context turns blue when broken. The habit is the only visible difference between this and *G. merulioides*. There may be a difference in the chemical characters, and there is one in ecology, since *Fraxinus americana*, the constant accompanying tree of *G. merulioides*, does not occur in Brazil. Yet it may well be that, as indicated by this author in previous papers, *G. Rompelii* is not specifically different from *G. merulioides*. In fact, the author has seen specimens from the southern hemisphere with lateral stipe. The absence of *Fraxinus* at its habitats and the fact that, between the geographic areas of *G. merulioides* and *G. Rompelii*, a gap is noticeable with *G. proximus* replacing the northern and the southern species in the tropical belt, prevent me from reducing *G. Rompelii* to synonymy.

Gyrodon merulioides (Schw.) Sing., Rev. de Mycol. **3**:172. 1938.
Daedalea merulioides Schwein., Trans. Amer. Phil. Soc. II **4**:160. 1832.
Paxillus porosus Berk. *in* Lea, Cat. Plants Cincinnati, Ohio, p. 54. 1839.
Boletus lateralis Bundy *in* Chamberlain, Geology Wisconsin **1**:398. 1883.
Boletinus porosus Peck, Bull. N.Y. State Mus. **8**:79. 1889, *incl. var. opacus.*
Boletinellus merulioides Murr., Mycologia **1**:7. 1909.

This species is so similar to *G. proximus* of Florida that a complete description of our collections appears to be necessary for the comparison of these plants.

Pileus olive brown or brown ("Isabella color" and "light brownish olive" in various combinations), often with darker portions or spots ("mummy brown" or deeper), also darker colored where handled, circular or elongate in circumference, dry, finely subflocculose or glabrous and like kid, or tomentose, or partly so, convex, eventually flattened or concave, 40–110 mm. broad. — *Hymenophore* "old gold" with a flush of "Isabella color," bluing where injured, becoming more brown or green when old or dry, boletinoid to submerulioid, some of the perpendicular walls not reaching the level of the radial (lamellose) walls, decurrent and forming an incomplete or complete wide network of veins on the very apex of the stipe, 4–14

mm. thick, pores irregular, angular, more radially elongate near the margin than farther inside, more than 1 mm. wide in middle zone (seemingly much wider than 1 mm. but the lower connecting walls inconspicuous, and therefore often not taken in consideration); spore print slightly deeper colored than "Isabella color" when quite fresh, and slightly lighter than this in an old print. — *Stipe* "buckthorn brown" and "yellow ocher" at apex, abruptly concolorous with the pileus in the lower portion, and there eventually almost black ("citrine drab" and "clove brown") in some specimens, the very base again paler in some cases, subglabrous, almost smooth, almost constantly either lateral or eccentric, rarely only slightly eccentric-subcentral, curved or straight, solid, 10–34 x 8–18 mm. — *Context* "baryta yellow" to "pinard yellow" in the pileus, "fawn color" to almost "army brown" in the base, often pale brown almost throughout the stipe, becoming dirtier here, and slowly bluing in the pileus when exposed; odor none, or of raw potatoes, or slightly spermatic.

Spores (6.8)–7–11 x 4.8–9.2 μ, mostly 7.5–10.5 x 5.8–9 μ, short-ellipsoid, with well-colored, somewhat thickened walls, smooth; *basidia* about 25 x 10–10.8 μ, 4-spored, with 3.5–4.2 μ long sterigmata; *cystidia* rare, not very conspicuous, cylindric, up to 6.5 μ broad; *trama* of the hymenophore truly bilateral; *cuticle* of the pileus of filamentous, 2–3.5 μ thick hyphae which are incrusted by the pigment, 3–4 μ thick in the cuticle of the stipe, some hyphae thickened up to 15 μ in diameter, and filled with a yellowish sap; most *hyphae* with clamp connections.

Chemical reactions: **KOH** on the surface of the pileus, a dusky mahogany brown; on context, light brown to very deep brown. — **NH_3** on surface of pileus, "Rood's brown." — **NH_4OH** on surface of pileus, very deep brown where it had been brown, more chestnut to paler tan where it had been more olivaceous; on context of pileus provoking the same color as the natural color of the context of the base of the stipe, or becoming dirty salmon color, or dirty gray; on tubes, "Mars brown" to "Prout's brown" (somewhat more sordid than these). — **H_2SO_4** on surface of pileus, as with KOH; on context and tubes, subferruginous. — **Phenol** on context, more blue than by mere autoxydation, eventually becoming brick red. — **$FeSO_4$** on context, olivaceous-green.

Habitat: In open woods and shaded lawns under *Fraxinus americana*, or in its neighborhood, on the soil, or on decayed wood of various trees, usually gregarious, fruiting from June to October.

Distribution: Common in most northeastern states, also in eastern Canada and south to Georgia and Alabama, west to Wisconsin.

G. merulioides has been studied by the author in numerous dried and fresh specimens. D. H. Linder (*in schedulis*) first brought the *Fraxinus*-relation to the author's attention, and then his own observations as well as W. H. Snell's independent experiences (orally to the author) confirmed this relationship. However, in artificial conditions of the laboratory, it is possible that this species may form mycorrhiza with other species than the above mentioned. In fact, it has been shown recently that a fungus de-

termined as *Boletinus porosus* forms mycorrhiza with pines. This, however, if it happens in the laboratory, is not likely to happen in nature.

Gyrodon spec.

One of the undetermined boletes in the Hoehnel Herbarium (FH), collected near Tjibodas, Java, in 1909 on a fern-trunk, *F. v. Hoehnel B.n. 1187* was examined by this writer, and found to belong in *Gyrodon*, more precisely in the *G. merulioides-Rompelii*-group, differing from both *G. merulioides* and *G. Rompelii* in the slender, eccentric stipe, and the much thinner pileus. The spores are 7.8–10.2 x 5.5–6.8 μ, short-ellipsoid, brownish, smooth. It is possible that the habitat is only incidental, and that there is *Fraxinus* near the place where it was collected (*Fraxinus* does occur on Java). It may also be that the thin pileus and slender stipe do not normally characterize the Javanese form. Therefore, I do not think it wise to publish it under a new specific name but merely wish to call the attention of other mycologists to the subject.

Gyrodon lividus (Bull. *ex* Fr.) Sacc., Syll. **6**:52. 1888.

Boletus lividus Bull. *ex* Fr., Syst. Mycol. **1**:389. 1821.
Boletus sistotrema Fr., Syst. Mycol. **1**:389. 1821, *non* Rostk. *in* Sturm.
Boletus brachyporus Pers., Mycol. Eur. **2**:128. 1825.
Gyrodon sistotremoides Opat., Comm. Hist.-Nat. Fam. Fung. Bolet., Wiegmann's Arch. **2**(1):5. 1836.
Boletus rubescens Trog, Flora **22**^{2}:449. 1839.
Boletus lividus ssp. alneti Lindgr. *ex* Fr., Hymen. Eur. p. 519. 1874.
Boletus lividus ssp. labyrinthicus Fr., Hymen. Eur., p. 519. 1874.
Boletus lividus var. rubescens Quél., Ass. Fr. Avanc. Sci., **1885,** p. 7. 1885.
Uloporus lividus Quél., Enchir., p. 162. 1886.
Uloporus lividus var. rubescens Quél., Enchir., p. 162. 1886.
Gyrodon lividus ssp. alneti Sacc., Syll. **6**:52. 1888.
Gyrodon lividus ssp. labyrinthicus Sacc., Syll. **6**:52. 1888.
Gyrodon rubrescens Sacc., Syll. **6**:52. 1888.
?*Boletus gyrosus* Pers., Mycol. Eur. **2**:138. 1825.
?*Boletus caespitosus* Mass., Brit. Fung. Flor. **1**:297. 1892.
?*Gyrodon caespitosus* Sacc., Syll. **11**:81. 1895.
?*Gyrodon Mikhnoi* Karst. (*descr. desid.*) *ex* Gilbert, Bolets, p. 104. 1931.

This is the only species known thus far from Europe but it has not been observed in America. For a description and plate see Kallenbach, Pilze Mitteleuropas **1**:109. *pl. 10, fig. 4–7*; *pl. 39, fig. 1–22*; *pl. 44, fig. 70–72*, and for the microscopical characters R. Singer, Rev. de Mycol. **3**:172. 1938.

SPECIES INCOMPLETELY KNOWN

Gyrodon purpureus (Beeli) Sing., Rev. de Mycol. **3**:171. 1938.

Favolus purpureus Beeli, Bull. Soc. Roy. Bot. Belg. **58**:213. 1926.
Boletinellus purpureus Gilbert, Bolets, p. 105. 1931.

This species from the Belgian Congo has been admitted in *Gyrodon* by this author conditionally ("Si ce que M. Gilbert affirme relativement au *Favolus purpureus* est exact . . ."), on the authority of Gilbert who has seen the type.

Gyrodon Ledermannii Kallenbach, Zeitschr. Pilzk. **8**:96. 1929, *ad int.*

Described from New Guinea, this species is too incompletely characterized.

SPECIES EXCLUDENDAE

Gyrodon capensis Sacc. is *Phlebopus capensis* (Sacc.) Sing.
Gyrodon castanellus (Peck) Sing. see under *Xerocomus squarrosoides* (Snell) Sing.
Gyrodon Emilei (Barbier) Killermann, Denkschr. Bayer. Bot. Ges. Regensb. **16**:22. 1925 is *Boletus spec.*, probably *B. aff. rubellus* Krombh.
Gyrodon filiae (Gill.) Sacc. & Cub. is *Boletus edulis* Bull. *ex* Fr. (a monstrosity)
Gyrodon fusipes (Heufl. *in* Rab. Exs.) Sacc. is *Suillus placidus* (Bon.) Sing.
Gyrodon immutabilis (Britz.) Sacc. & Trott. is a *Boletus* spec., possibly *B. appendiculatus*; according to Killermann, it is *Phlebopus sulphureus* (Fr.) Sing.
Gyrodon miramar (Roll.) Sacc. & Trott. is *Suillus granulatus* (L. *ex* Fr.) Kuntze (*sec.* Konrad & Maublanc)
Gyrodon Mougeotii (Quél.) Sacc. is *Boletus pulverulentus* Opat. (*sec.* Konrad & Maublanc)
Gyrodon Oudemansii (Harts. *in* Flor. Bat.) Sacc. is *Suillus placidus* (Bon.) Sing.
Gyrodon placidus (Bon.) Sacc. is *Suillus placidus* (Bon.) Sing.
Gyrodon rubellus McWeeney *fide* Rea is not a *Gyrodon*.
Gyrodon volvatus (Pers.) Opat. is a parasitized or anomalous *Amanita* spec.

Subfam. **Suilloideae** Sing. subfam. nov.

Hyphis fibuligeris vel haud fibuligeris; hymenophoris boletinoideis (parietibus lamellose i.e. radialiter dispositis) aut velatis aut glandulosis (glandulis numerosioribus ad stipitem) aut — si characteribus his carent — pellicula viscosissima praesente et tunc sporis constanter minoribus, pallide melleis elongatis, cystidiisque plerumque incrustatis et majusculis, stipite plerumque cylindrico vel subcylindrico, hymenophoro plerumque haud distincte depresso circum stipitis apicem et tramate distincte bilaterali praedito; si autem his characteribus haud clare gaudet, tubuli ex integro rubidi sunt. Habitatio: Cum arboribus coniferis mycorrhizam formant.

Characters of the subfamily: see key, p. 226, and Latin diagnosis.

The genera *Boletinus*, *Psiloboletinus*, and *Suillus* have very decidedly a close and natural affinity notwithstanding the difficulties one experiences in briefly outlining the characters they have in common, as may be seen in the above Latin description of this subfamily. When working on these fungi one cannot fail to notice that there is a much closer relationship between all these genera than between any one of them and any other boletaceous genus.

5. **Psiloboletinus** Sing. gen. nov.

A genere *Boletino* veli absentia et hymenophoro magis lamelloideo marginem pilei versus differt.

Characters of the genus: see key p. 226 and the above Latin diagnosis. The type species is **P. lariceti** (Sing.) Sing. comb. nov. (*Phylloporus lariceti* Sing.)

At the time of the discovery it seemed wiser to refrain from the erection of a new genus for what we then called *Phylloporus lariceti*. A more pro-

found study of the affinities of this species, however, as well as of *Phylloporus rhodoxanthus* has become possible since then and, as a result, we now propose to base a new genus of Suilloideae on the former while the latter enters the subfamily Xerocomoideae as the type species of *Phylloporus*. The ecology and the chemical characters of *P. lariceti* and *P. rhodoxanthus* make this disposition necessary. *Psiloboletinus* does not occur in Florida.

6. **Boletinus** Kalchbr., Bot. Zeit. **25**:182. 1867.

Euryporus Quél., Enchir. p. 163. 1886. Type, *E. cavipes* (Opat.) Quél.

Characters of the genus: Pileus fibrillose to squamose, or even squarrose, the fibrils or scales not superimposed upon a viscid layer and therefore not easily detersible as fragments of a veil, the surface decidedly dry even in wet weather except for *Boletinus spectabilis* when the pileus becomes viscid starting from the margin and gelatinizing inwards; spores comparatively small to medium (up to 13.2 μ in our measurements) pale melleous with occasional darker spores, cystidia voluminous and mostly covered by a resinous colored incrustation; clamp connections potentially present in most species, i.e. at least some populations or carpophores of a majority of species have at least some scattered clamps while in some species a majority of specimens does not show clamps at all, and in some species, clamp-bearing specimens have not yet been found; hymenophore more (in the majority of cases) or less (especially in *B. amabilis* and *B. pictus*) boletinoid, *i.e.* pores radiately arranged and rather long, the radial walls lamella-like, especially toward the stipe; stipe usually cylindric or subcylindric and constantly without glandulae (some glandulae might however be seen on the pores if a lens is used); veil always present though not always persistent and not regularly forming an annulus, either simple or double; mycelium connected with certain conifers (*Pinus*, *Larix*, *Picea*, *Pseudotsuga*) with which all Boletini are associated, forming mycorrhiza. The type species is *Boletinus cavipes* (Opat.) Kalchbr. (*Boletus cavipes* Opat.).

KEY TO THE SUBGENERA AND SECTIONS

A. Stipe hollow, or, if solid, the pores comparatively extremely wide; mycorrhiza always with *Larix*; clamps constant. Subgenus *Eu-Boletinus*

B. Stipe hollow. Sect. *Cavipedes*

B. Stipe solid. Sect. *Palustres*

A. Stipe solid; pores medium-wide to wide, not as wide as in the sect. *Palustres* if the size of the pileus is considered; clamps either not constant, or very scattered, or even entirely absent in all the material studied thus far. Subgenus *Aporpiellus*

C. Veil duplex, the interior veil gelatinizing and forming a glutinous inner layer of the annulus and a viscid marginal zone in older specimens. Sect. *Spectabiles*

C. Veil simple or double but neither layer gelatinizing with age. Sect. *Solidipedes*

Subgen. **Eu-Boletinus** Sing. subg. nov.

Hyphis fibulis numerosis constanter instructis; stipite interdum cavo; mycorrhiza cum larice.

Characters of the subgenus: see key and Latin diagnosis above. Type species *Boletinus cavipes* (Opat.) Kalchbr.

Sect. **Cavipedes** Sing., Rev. de Mycol. **3**:163. 1938.

Characters of the section: Stipe hollow; pileus squamose; hymenophore strongly boletinoid, pores wide but not as extremely wide as in the *Palustres*; veil not gray; gelatinizing surfaces absent; spores often small (smaller than 10 μ in a majority of cases); clamp connections numerous and constant; context unchanging. The type species is *B. cavipes* (Opat.) Kalchbr. Another species is *B. asiaticus* Sing. None of these has been observed in Florida.

Sect. **Palustres** Sing., Rev. de Mycol. **3**:162. 1938.

Characters of the section: Stipe solid; pileus squamose; hymenophore strongly boletinoid, pores extremely wide in comparison with the size of the pileus; spores small (smaller than 10 μ); clamp connections numerous and constant; hyphae of the cuticle with a wall of about 1 μ diameter, grayish-fuscous in ammoniacal medium; context unchanging on the air but somewhat more readily reacting with chemical reagents, especially $FeSO_4$.[9] Type species *B. paluster* (Peck) Peck. No representatives are known in Florida.

Subgen. **Aporpiellus** Sing. subg. nov.

Fibulis haud praesentibus in omnibus carpophoris (i.e. inconstantibus) et si adsunt, haud praesentibus in omnibus septis (i.e. infrequentibus); stipite nunquam cavo; mycorrhiza cum larice et aliis arboribus coniferis.

Characters of the subgenus: See key and Latin diagnosis above. Type species *B. pictus* (Peck) Peck.

Sect. **Spectabiles** Sing., Rev. de Mycol. **3**:157. 1938.

Characters of the section: Veil duplex, i.e. interior veil membranaceous and gelatinizing in the annulus and on the margin of the pileus; exterior layer squamulose; hyphae of the pileus thin-walled; stipe solid; clamp connections none, or in some specimens present though very rare. The only species known is *B. spectabilis* Peck, forming mycorrhiza with larch, and therefore not occurring in Florida.

[9] In *B. paluster*, the "carmine" color of the scales becomes more vivid with formol which also provokes at times a very slight reddening of the context; KOH on surface of pileus black for about 1 second, then pale brownish; on context red for about one second, then lilac, then sordid; NH_4OH on surface of pileus, darker and then quickly bleached; on context, darker yellow; $FeSO_4$ on stipe, greenish gray. The whitish yellow to lemon yellow context of the pileus, and the pale orange context of the stipe, the more reddish context of the base and the "Isabella color" pores and tubes are not subject to autoxydation.

Sect. **Solidipedes** Sing., Rev. de Mycol. **3**:158. 1938.

Characters of the section: Veil double or simple but not showing different consistency in age, the whole plant remaining dry, never viscid, or scarcely so; stipe solid, eventually sometimes slightly excavated; pores wide (about as wide as in the sect. *Cavipedes*, or smaller), in two species (*B. amabilis*, *B. pictus*) not quite as distinctly boletinoid as usual in the other sections; veil frequently tending to be or to become gray. Type species *B. pictus* (Peck) Peck.

This section is the one richest in species, and also shows the greatest variation in distribution and in ecologic requirements. The author formerly (Rev. de Mycol. **5**:6. 1940) transferred *Boletus Lakei* to *Ixocomus* (i.e. *Suillus*) but further studies on this species and allied forms have shown that it belongs in *Boletinus* rather than *Suillus*. It grows with *Pseudotsuga*. *B. Benoisii*, *B. grisellus*, most forms of *B. oxydabilis* and *B. ochraceoroseus* grow with larch and *B. amabilis* has been indicated with *Picea*. Naturally, these species do not occur in Florida. Of the species associated with pine, *B. pictus* does not occur so far south, thus only *B. decipiens* is found in the pine woods of this state.

KEY TO THE SPECIES

A. Context distinctly and strongly (in young fresh specimens) changing color when bruised; annulus often gray or tending to become so; mycorrhiza with *Pinus*, or with *Larix sibirica* or *L. dahurica*; pileus "Vandyke red" to "acajou red" when young, if growing with pine.

B. Mycorrhiza with *Pinus*. *B. pictus*

B. Mycorrhiza with *Larix*.

C. Pileus deep raspberry-red to bright brick red; mycorrhiza with *Larix dahurica*. *B. Benoisii*

C. Pileus merely with an occasional purplish brick color shade; mycorrhiza with *Larix sibirica*. *B. oxydabilis*

A. Context slightly changing color over very limited areas when broken, or indistinctly and inconstantly discolored after rather long exposure to the air, or not changing at all; annulus not gray; pileus never entirely "Vandyke red" or "acajou red"; fungi forming mycorrhiza with *Pinus*, *Larix* (but not *L. dahurica* nor *L. sibirica*), *Pseudotsuga*, *Picea*.

D. Mycorrhiza with *Larix occidentalis* and other species of *Larix*.

E. Spores around 4–5 μ broad; pileus never pinkish. *B. grisellus*

E. Spores around 3–3.5 μ broad; pileus inclining to pink. *B. ochraceoroseus*

D. Mycorrhiza with other conifers than *Larix*.

F. Mycorrhiza with *Pseudotsuga* or *Picea*; western species.

G. Spores around 4.2 μ broad and (9.5)–11–(12.3) μ long. *B. amabilis*

G. Spores around 3.5 μ broad and (7)–8.5–(10.7) μ long. *B. Lakei*

F. Mycorrhiza with *Pinus*; eastern species. 7. *B. decipiens*

DESCRIPTION OF THE FLORIDA SPECIES

7. **Boletinus decipiens** (Berk. & Curt.) Peck, Bull. N.Y. State Mus. **8**:78. 1889.

Boletus decipiens Berk. & Curt., Ann. Mag. Nat. Hist. II, **12**:430. 1853.
Suillus decipiens Kuntze, Rev. Gen. Plant. **3**^{2}:535. 1898.
Boletinus Berkeleyi Murr., Mycologia **1**:6. 1909.
Boletinus floridanus Murr., Lloydia **6**:224. 1943.

PLATE I, FIG. 5–7.

Pileus "maize yellow" or paler, with "cinnamon buff" or "clay color" scales, sometimes becoming somewhat "Verona brown" after rains, not viscid at any time, the scales irregular, rather small (1–2 mm. in diameter), appressed, the surface convex, not or indistinctly umbonate, 35–70 mm. broad. — *Hymenophore* "deep colonial buff," nearing "honey yellow" when mature, typically boletinoid and very compound, adnato-decurrent, the decurrent tooth running down over about one third to one half of the stipe's length, and this decurrent portion usually entirely covered by the veil, tubes moderately long, pores concolorous. — *Stipe* "cinnamon buff," or, especially below, "pinkish cinnamon," frequently with some "Sudan brown" below, with an incomplete and not quite constant network immediately below the fertile zone of the apex, solid, tapering downwards, 30–36 x 10–12 mm.; veil "pale pinkish buff" to "tilleul buff," apical, dry, fibrillose, appressed, rarely forming a well-developed annulus; mycelium sordid. — *Context* of the pileus and the apex of the stipe "pinkish buff," of the middle of the stipe "straw yellow," of the base "orange cinnamon," most of the context unchanging but at places becoming "vinaceous tawny" (reddening) in the pileus on prolonged exposure; odor agreeable but different from the agreeable odor of the Suilli, not strong; taste mild.

Spores 7–10.5 x 3–4.2 μ, mostly 8.7–9.5 x 3.5–3.7 μ, pale brownish or pale melleous, smooth, more or less cylindric to subfusoid or subellipsoid, decidedly asymmetric, with rather thin wall; *basidia* 24–30 x 6–8.5 μ, 4-spored, the spores formed on sterigmata of the usual shape (half-sickle-shaped), 7 μ long; *cystidia* up to 50 x 13 μ, usually clavate to subfusoid, incrusted by a ferruginous-fulvous, rarely hyaline incrustation; *tramal hyphae* without clamp connections, truly bilaterally arranged; *hyphae of veil* clampless, 1.5–8 μ in diameter; *hyphae of the cuticle* in interwoven strands of parallel filaments, hyaline, with hyaline or brown punctate incrustations or entirely golden-ferruginous at places, the terminal members often clavate, many with a mucilaginous incrustation, the walls very thin to moderately thick, the diameter 3–11 μ, the septa without clamps.

Chemical reactions: **KOH** on surface of pileus, green-black; on context of stipe, green-black, almost black; **NH_3** on surface of pileus, pink and on context of stipe, "cinnamon russet"; **NH_4OH** on surface of pileus, rusty-brown or after a short time becoming sordid blackish lilac; on context of stipe, "cinnamon russet," then slowly almost black; **HNO_3** on surface of pileus, negative; on context of stipe, "cinnamon rufous"; **$FeSO_4$** in all parts, slowly black.

Gastroid condition: Some of the smaller carpophores of the same mycelium do not, at some localities, open up at all and remain indefinitely in a Gasteromycete-like condition; they are piriform with columella (stipe) and labyrinthiform loculi (hymenophore) confined to the underside of a pileate portion of the peridium (pileus), producing spores of the same size (7–9.5 x 3–3.8 μ), shape, and color, on basidia of the same type as in the pseudoangiocarpous form.

Habitat: On the ground in flatwoods and in sphagnose swamps under *Pinus palustris*, *P. caribaea* and possibly other species.

Distribution: Southeastern states of the U.S.A. north to New Jersey and west to Kentucky (according to Murrill); occurring throughout Florida but rarely collected.

Material studied: **Fla.** Alachua Co. east of Gainesville, July 20, 1943, *R. Singer, F 2840* (FH); Lake Co., Eustis, Oct. 1897, *R. Thaxter* (det. Singer) (FH); Dade Co., Addison Hammock, February 2, 1906, *J. K. Small* (det. W. A. Murrill) (NY). **S.C. type** and **authentic** material from Society Hill and Santee Canal (*1312*) and *Ravenel (401)* (FH). **Ala.** Auburn, *F. S. Earle* (FH); other specimens in the herbaria consulted are not in good condition, and have therefore not been studied carefully, or they obviously belong to other species such as *Xerocomus squarrosoides* (Snell) Sing. or *Gyrodon merulioides*, etc.

Peck correctly transferred this species to *Boletinus*. Whether his own collections belong to *B. decipiens* is not quite certain, but inconsequential. Specimens in the Curtis Herbarium, collected by Peck, are not too convincing, and may belong to *B. pictus*. Material from Maine may belong to *B. cavipes*. All Massachusetts material known to me is *Xerocomus squarrosoides*.

The existence of gastroid forms is considered by this author as an additional evidence of the affinity of the Boletineae and certain Gasteromycetes. These forms are fructifications with incomplete individual development, not reaching the second gymnocarpous stage characterizing *Boletinus* in general. If the Boletineae as a whole are, as this writer thinks, derived from certain Gasteromycetes such as *Truncocolumella* and related forms, it would follow that the gastroid forms of *Boletinus decipiens* are atavistic aberrations whose formation may be favored by climatic factors, e.g. sudden decrease in humidity during the fruiting period. Specimens were sent to Dr. S. M. Zeller of Corvallis, Oregon with the pointed question as to similarity with gasteromycetous genera. Dr. Zeller replied that "the gasteromycetoid stage of *Boletinus decipiens* was received in good condition. It comes closer to *Truncocolumella* than any other described genus of Gasteromycetes, I believe." It ought to be noted well that this comes from the author of the genus *Truncocolumella*, an undoubtedly gasteromycetous genus with the spores borne acrogenously on the sterigmata. It is worth remembering that this genus had been described, shortly afterward, as *Dodgea* by Malençon, and that *Dodgea* was the main subject of discussions on boletinoid affinities by Malençon and this author. With these facts at hand, it

would certainly not be a scientific approach to shut the eyes and talk of convergence.

EXTRALIMITAL SPECIES

Boletinus pictus (Peck) Peck, Bull. N.Y. State Mus. **8**:77. 1889.

Boletus pictus Peck, Ann. Rep. N.Y. State Cab. **23**:128. 1872.
Boletus Spraguei Berk. & Curt., Grevillea **1**:35. 1872.
Boletus Murraii Berk. & Curt., Grevillea **1**:36. 1872.

The pileus of fresh material is "Vandyke red," margin "acajou red," scales "burnt lake," later "Pompeian red" with the scales "brick red," and the yellow of the flesh showing through; pores somewhat paler and yellower than "old gold"; stipe "acajou red" above or "acajou red" to "brick red," or with the base "brick red" to "Hessian brown" (actually this is the color of almost reticulate fibers which are appressed to the "antimony yellow" to "light orange yellow" ground); mycelium dirty whitish; context of the pileus "straw yellow," soon becoming clouded with pinkish to grayish, context of the stipe "mustard yellow," of the base "ochraceous tawny," soon becoming more "tawny" because of autoxydation; veil densely cortinoid-fibrillose, initially "light pinkish cinnamon" becoming "tilleul buff" and eventually gray in the outermost layer. — KOH on flesh of pileus, deep olive, becoming blackish olive to black; $FeSO_4$ on flesh of pileus, deep sordid olive; formol on flesh of pileus, incarnate; NH_4OH as with KOH but reaction weaker.

Boletinus Benoisii (Lebedeva *ex*) Sing., Rev. de Mycol. **3**:159. 1938.

Occurring under *Larix* instead of under pines, this seems to be specifically different from *B. pictus*.

Boletinus oxydabilis Sing., Rev. de Mycol. **3**:160. 1938.

For the complete data on this species and its variety see the original description (*l.c.*) of the Siberian type.

Boletinus grisellus Peck, Mem. N.Y. State Mus. **3**:169. 1900.

Described from Massachusetts, but rather profusely distributed, this species has been described by Peck (*l.c.*), Murrill (N. Am. Fl. **9**(3):159. 1910), Singer (*l.c.* p. 162), and others. Type specimens are preserved (NYS, FH).

Boletinus ochraceoroseus Snell, Mycologia **33**:35. 1941.

Described from Idaho, this species has later been proved to be associated with *Larix* (see Slipp & Snell, Lloydia **7**:18. 1944). The type (FH) appears to be different from *B. Lakei* and *B. amabilis*.

Boletinus amabilis (Peck) Snell, Lloydia **7**:17. 1944.

Boletus amabilis Peck, Bull. Torr. Bot. Club **27**:612. 1900.

Described from spruce woods in Colorado, part of the type is preserved

at FH, and the spores were found to be decidedly larger than in *B. Lakei.* Judging from what material I had, I found it difficult to believe that *B. amabilis* as described by Slipp & Snell (*l.c.*) is the same as the type of this species. The description fits much better in *B. Lakei* which actually is associated with *Pseudotsuga.* Whether or not this and the following species are races or forms, cannot be decided with certainty.

Boletinus Lakei (Murr.) Sing. comb. nov.

Boletus Lakei Murr., Mycologia **4**:97. 1912.

Ixocomus Lakei Sing., Rev. de Mycol. **5**:6. 1940.

Though the specimens received by this author in 1939 from Dr. Alexander H. Smith were identical with the type specimens (NY), they do not seem to belong in *Suillus* now that the related species, *B. amabilis* and *B. ochraceoroseus*, have been studied and found to belong in *Boletinus.* The section *Pseudotsugini* of *Ixocomus* is therefore to be abandoned as a synonym of the section *Solidipedes* of *Boletinus.*

SPECIES INCOMPLETELY KNOWN

Boletinus appendiculatus Peck, Bull. Torr. Bot. Club **23**:418. 1896, from Washington, D. C.

Boletinus solidipes Peck, Bull. N.Y. State Mus. **167**:38. 1912, from Maine.

Boletinus subgrisellus Sing. *ad int.*, Ann. Mycol. **40**:27. 1942 *nom. subnud.*

Boletinus glandulosus Peck, Bull. N.Y. State Mus. **131**:34. 1909, from Nova Scotia.

SPECIES EXCLUDENDAE

Boletinus castanellus Peck.

This is hardly a *Boletinus.* No type is preserved and the species, as understood by some is *Gyrodon merulioides*, or as understood by others, e.g. Coker and Beers, is *Xerocomus squarrosoides* (Snell & Dick) Sing.

Boletinus flavoluteus Snell *apud* Snell & Dick is a *Suillus.*

Boletinus merulioides (Schw.) Coker & Beers, is a *Gyrodon, G. merulioides.*

Boletinus porosus (Berk. *in* Lea) Peck is also *G. merulioides.*

Boletinus punctatipes Snell & Dick is *Suillus punctatipes.*

Boletinus squarrosoides Snell & Dick is not a *Boletinus.* It can be considered as either a *Phylloporus* or a *Xerocomus, X. squarrosoides* (Snell & Dick) Sing.

7. **Suillus** Micheli *ex* S. F. Gray, Nat. Arr. Brit. Pl. **1**:646. 1821 emend. Snell, Mycologia **34**:406. 1942.

Pinuzza Micheli *ex* S. F. Gray, *l.c.* (type *Pinuzza flava* (Bolt.) S. F. Gray)

Rostkovites Karst., Rev. Mycol. **3**:16. 1881 (proposed lecto-type *R. granulatus* (L.) Karst.)

Cricunopus Karst., *l.c.* (proposed lecto-type *C. luteus* (L.) Karst.)

Boletus Dill. *ex* Fr. *sensu* Karst., *l.c.* p. 17, *non* S. F. Gray.

Viscipellis Quél., Enchir. p. 155. 1886 (proposed lecto-type *V. lutea* (L.) Quél)
Versipellis Quél., *l.c.* p. 157 [10]
Ixocomus Quél., Flore Mycol. p. 411. 1888 (proposed lecto-type *I. luteus* (L.) Quél.)

Characters of the genus: Hyphae of the pellicle strongly gelatinized; spores usually small; cystidia usually rather large, incrusted; pileus more or less viscid to glutinous; pores small and round to very wide and boletinoid; tubes adnate and rarely slightly depressed around the stipe, more often subdecurrent or decurrent; trama of the hymenophoral walls truly bilateral, of the *Boletus*- or *Boletinus*-type, not of the *Phylloporus* type; stipe usually more or less cylindric, with or without glandulae (consisting of fascicles of dermatocystidia, or consisting of hyphae terminating in dermatocystidia of two types, dermatopseudoparaphyses and dermatobasidia); spore print either between "ochraceous tawny" and "Isabella color" or a rather deep olivaceous; veil either present or absent, either entirely glutinous-gelatinous, or membranaceous and viscid when wet; mycorrhiza with conifers only. The type species is *S. luteus* (L. *ex* Fr.) S. F. Gray (*Boletus luteus* Linné *ex* Fr.).

From viscid species of *Pulveroboletus*, this genus differs in several regards, *either* by the characters of the veil, indicated above, *or* by the more boletinoid hymenophore if the pores are wide, *or* by forming mycorrhiza with coniferous trees instead of frondose trees, or by a combination of characters like these. The presence of a viscid veil, or glands, or red hymenophore, or boletinoid hymenophore on a species which is constantly associated with conifers suffices to consider it as a *Suillus*, if it is *not* a *Boletinus* (see key, p. 226). The only *Pulveroboletus* known to have a glutinous veil, *P. corrugatus* (Pat. & Baker)Sing. (*Boletopsis corrugata* Pat. & Baker) is a tropical Asiatic species, not associated with conifers. Similar characters or alternative characters or combinations of characters delimit *Suillus* from viscid species of other genera (*Xerocomus badius*, *X. brasiliensis*, *Leccinum rubropunctum*, *L. chalybaeum*, *Boletus Frostii*, *Tylopilus plumbeoviolaceus*, and others) of the Boletaceae, and *Boletellus* of the Strobilomycetaceae.

The author has formerly divided the present genus into four sections, and though he has studied numerous additional species since then, he still sees no reason to change this very workable and natural arrangement. The largest section, *Granulati*, in fact the only one that occurs in Florida, has been subdivided by this author in two subsections. In the light of recent studies it appears that a third subsection should be added in order to take care of the species with weak alkali-reactions and deeper olive spore print,

[10] It is here proposed to accept Murrill's proposal to choose the first species of the genus *Viscipellis*, *V. variegata*, as type of the genus. *Versipellis* also contains elements of *Xerocomus* and *Boletus*, *Phlebopus*, etc. The same approach was also thought to be most practical in the case of the genus *Rostkovites* Karst.

i.e. *S. hirtellus*, *S. punctipes*, *S. cembrae*. The sections and subsections of *Suillus* represent themselves, thus, in the following way:

KEY TO THE SECTIONS AND SUBSECTIONS

A. Stipe with a veil, without glandulae; mycorrhiza with *Larix*. Sect. *Larigni*

B. Pores usually grayish or cinnamon-orange, rarely yellowish, more than 1 mm. in diameter, rarely about 1 mm. in diameter. Subsect. *Megaporini*

B. Pores yellow to ochraceous-olive, less than 1 mm. in diameter, reaching 1 mm. only in old, large fruiting bodies. Subsect. *Leptoporini*

A. Stipe either without a veil, or with glandulae, or, at the same time, without a veil and with glandulae; mycorrhiza with *Pinus*, *Picea*, *Abies*, *Pseudotsuga*, *Tsuga*, and possibly with other conifers, not with *Larix*.

C. Glandulae present (except sometimes in *S. brevipes* where they may be so indistinct as to appear lacking); if they are seemingly absent, the stipe remains white for a long time. Sect. *Granulati*

D. Spore print between "ochraceous-tawny" and "Isabella color"; pores small to wide; context of the pileus with a distinct reaction with NH_3 (red or lilac); pileus without innate fibrils and squamulae.

E. Pores more than 1 mm. in diameter or about 1 mm. wide; veil present but often either gelatinized and entirely glutinous, or reduced to a marginal veil that is rather fugacious. Subsect. *Latiporini*

E. Pores small, decidedly below 1 mm. in diameter (some pores may become 1 mm. in diameter when old in very large specimens); veil well developed, or indistinct, or absent. Subsect. *Angustiporini*

D. Spore print deeper olive; pores around 1 mm. in diameter, occasionally either less or more; context of the pileus with a markedly weak reaction with NH_3 (almost or quite negative at first, after very long exposure becoming sordid to gray or violet); pileus with an innate fibrillosity at least at first, or fibrillose-squamulose-hirtose. Subsect. *Hirtellini*

C. Glandulae entirely lacking; stipe colored from the beginning.

F. Pores and tubes not reddish in fresh condition. Sect. *Bovini*

G. Pores large (larger than 1 mm. in diameter); pileus not squamulose; context with NH_3 dark rose, then red, and eventually brownish vinaceous. Subsect. *Euryporini*

G. Pores small to medium (1 mm. or slightly less in diameter); pileus squamulose; context reacting indistinctly with NH_3 (reddish-lilac) Subsect. *Stenoporini*

F. Pores and at least a portion of the tubes colored a dull red or rose-red in fresh condition. Sect. *Piperati*

Sect. **Larigni** Sing., Rev. de Mycol. **3**:38. 1938.

Characters of the section: see key. Type species: *Suillus Grevillei* (Kl.) Sing. (*Boletus Grevillei* Kl.), also type of subsect. *Leptoporini* Sing. *l.c.*

Subsect. **Megaporini** Sing., Rev. de Mycol. **3**:41. 1938.

Characters of the subsection: see key. Type species: *Suillus aeruginascens* (Secr.) Snell (*Boletus aeruginascens* Secr.). Other species: **Suillus**

flavus (With. *ex* Fr. *sensu* Bres., Nüesch) Sing. comb. nov. (*Boletus flavus* With. *ex* Fr. *emend.* Bres., *Ixocomus flavus* (*sensu*) Sing.); **S. tridentinus** (Bres.) Sing. comb. nov. (*Boletus tridentinus* Bres.). None of these have been observed in Florida.

Sect. **Granulati** Sing., Rev. de Mycol. **3**:38. 1938.

Characters of the section: see key. Type species: same as type of genus.

Subsect. **Latiporini** Sing., Rev. de Mycol. **3**:45. 1938.

Characters of the subsection: see key above. Type species: **Suillus flavidus** (Fr. *ex* Fr.) Sing., comb. nov. (*Boletus flavidus* Fr.). Other species: **S. sibiricus** (Sing.) Sing. comb. nov. (*Ixocomus sibiricus* Sing.); *S. americanus* (Peck) Snell; *S. subaureus* (Peck) Snell; *S. flavoluteus* (Snell) Sing. comb. nov. (*Boletinus flavoluteus* Snell), and some more, none of them occurring in Florida.

Subsect. **Angustiporini** Sing., Rev. de Mycol. **3**:45. 1938.

Characters of the subsection: see key above. Type species: *S. granulatus* (L. *ex* Fr.) S. F. Gray.

KEY TO THE SPECIES [11]

A. Glandulae manifest, in occasional forms with indistinct glandulae and then stipe elongate (longer than the diameter of the pileus) and mycorrhiza not formed with 2-needle pines (at least in nature).

B. Veil present, forming a distinct and constant though not always persistent annulus.

C. Stipe about six times longer than thick, or more, with numerous glandulae almost to the base; annulus small to medium sized, not very distant, and not broadly sheathing, pallid and frequently appressed, sliding down in some instances; mycorrhiza with 5-needle pines (*Pinus strobus* and *P. monticola*). *S. subluteus*

C. Stipe and annulus not as described above; mycorrhiza with 2-needle pines (in nature).

D. Context a warm yellow; annulus very strikingly sheathing and not distant in its free part; mycorrhiza with *Pinus taeda*, *P. palustris*, *P. australis*. 8. *S. cothurnatus*

D. Context white to partially lemon yellow; annulus sheathing but widely distant in its free portion when normally developed in not too old specimens; mycorrhiza in nature with *Pinus pinea*, *P. silvestris*, *P. nigra*, *P. montana*, *P. resinosa*. *S. luteus*

B. Veil absent or indistinct, never forming annulus.

E. Pileus white or white for the most part and for a very long period; stipe elongate; NH_3-reaction red in mature specimens; mycorrhiza with 5-needle pines. *S. placidus*

[11] This key, as usual, takes into account all species known to the author, and will be useful to determine, in this particular case, those species occurring in the eastern United States, eastern Canada, and Europe.

E. Pileus yellow to brown, more rarely initially white but soon with brown and eventually often with yellow shades, or pallescent from the center; stipe short or elongate; NH_3-reaction not distinctly reddish in mature (though not too yellow) context; mycorrhiza with various sections of *Pinus*.

F. Spores larger than 8.2 μ. European and African races of *S. granulatus*.

G. Central and North European form with elongate stipe, yellow to yellowish brown pileus, and concolorous glandulae which become darker only in some specimens and then very late; preferring calcareous soil; associated with *Pinus silvestris* and *P. montana*. *S. granulatus* ssp. *typicus*

G. Mediterranean form with short stipe, white to yellowish brown or fuscous pileus, strongly colored grandulae, and preference for sandy soil, not growing with *Pinus silvestris* in nature. *S. granulatus* ssp. *leptopus*

F. Spores smaller than 8.2 μ; associated with *Pinus strobus* (and *P. monticola* ?), rarely with other conifers such as *Abies*.

H. Glandulae conspicuous, not limited to the apex of the stipe; tubes adnate; veil rarely present. *S. granulatus* ssp. *Snellii*

H. Glandulae minute, present only at apex of stipe; tubes decurrent; veil marginal, usually rather distinct. *S. albidipes*

A. Glandulae very indistinct and small, pallid to brownish, confined to the upper third of the frequently very short stipe, or more often entirely lacking, at least to the unaided eye; mycorrhiza with 2-needle pines. 9. *S. brevipes*

DESCRIPTION OF THE FLORIDA SPECIES

8. **Suillus cothurnatus** Sing. spec. nov.

PLATE I, FIG. 8–10.

Pileo approximate coloribus *S. lutei* gaudente, viscoso, glabro, levi, 16–63 mm. lato; tubulis ochraceo-alutaceis, olivascentibus in vetustis, poris subconcoloribus, exiguis; sporis 7.5–9.8 x 2.7–3.5 μ, levibus, pallide melleis; stipite albido, griseolo, pallide aurantiaco-flavello, saepe fuscescente, glandulis pallidis fulvescentibus vel nigrescentibus adornato, solido, annulato, 23–40–(60) x 4–11–(13) mm.; annulo pallido, olivascente vel grisente, ample cothurnante, membranaceo, viscido; mycelio salmoneo; carne marmorata, aurantiaco-alutacea vel aurantiaca atque carneo-alutaceo-flammata, vel pallide alutaceo-maculosa. Habitatio: Prope pinus (*Pinus australis*, *P. palustris*, *P. taeda*) in Florida Americae Borealis. Distinguntur duae subspecies, ssp. **aestivalis** Sing. (subspecies typica) stipite elongato, et ssp. **hiemalis** Sing., stipite breviusculo.

Ssp. **aestivalis** Sing. (type subspecies), ssp. nov.

Pileus "ochraceous buff" and "ochraceous tawny," or "cinnamon buff" and "clay color," or just "cinnamon buff," viscid, glabrous, smooth, naked, sometimes marbled in these colors, subconic or convex-subumbonate, or eventually with flattened center, 16–40 mm. broad. — *Hymenophore* "ochraceous buff" to "colonial buff" towards the margin, more rarely all over, with "capucine orange" spots, or between "orange buff" and "light orange yellow" tending to "yellow ocher" when maturing, or near "honey

yellow" when mature, adnate with a more or less pronounced decurrent tooth; tubes about 4 mm. long; pores concolorous, irregular, some radially elongate and 0.5–1.0 mm. wide in radial direction but never wider than 0.5 mm. transversely. — *Stipe* brownish white to white, then sordid grayish white, or assuming yellowish or pale orange yellow hues, finally sometimes darkening to "hair brown," glandulose, with the dots being all equally large or larger above the annulus (and then more scattered than below), brownish becoming badious, tawny, or vinaceous brown, inside solid, equal or tapering downward, 23–40 x 4–7 mm.; mycelium salmon color; veil connecting the margin with the apex of the stipe and running down the stipe, initially white near the stipe and more glutinous-hyaline near the margin, disrupted in this latter zone, the inner, lower portion forming an annulus which sheathes the stipe and has a strong tendency to become inversely infundibuliform (wider below), becoming sordid-white and then gray on maturing, more rarely with an olivaceous shade, viscid when wet (the covering gluten colorless), as high as broad or slightly reflexed-horizontal. — *Context* marbled "orange buff" and "light buff," unchanging, soft and somewhat watery; odor as in *S. punctipes* (agreeable), or none; taste not significant.

Spores 7.8–9.8 x 2.7–3.2 μ, most frequently 8.3–8.5 x 2.8–3 μ, pale melleous, smooth, ellipsoid-oblong to subcylindric; *basidia* 19–22 x 5.8–6.8 μ, 4-spored; *cystidia* 40–68 x 6.5–10.3 μ, strongly to moderately strongly incrusted, mostly elongate-clavate to broadly clavate, more rarely more fusoid or cylindric, or varying frequency even on the pores; *trama* truly bilateral; *pellicle* an "ixotrichodermium"; *dots* of the surface of the stipe consisting not only of the ordinary dermatocystidia of the *Suillus*-type but also of hyaline structures recalling the scales of *Leccinum* (*Krombholzia*) showing parallel, multi-septate hyphae terminating in a palisade of sterile, large basidium-like bodies (dermatopseudoparaphyses), and cystidia-like bodies (dermatocystidia of the *Leccinum*-type, *i.e.* rather small, hyaline, ampullaceous with narrowed bases); all *hyphae* without clamp connections.

Chemical reactions: **KOH** on surface of pileus "bone brown"; on pores dark dull lilaceous; on context of pileus "dark purple drab"; on context of stipe "dull Indian purple" or "deep purplish vinaceous"; on glandulae dark lilac. — **NH_3** on surface and context of pileus and on pores little or slow reaction, especially in young specimens; on cortex of stipe "vinaceous rufous" when quite mature. — **NH_4OH** on surface of pileus "cinnamon drab"; on context of pileus "cinnamon drab" or indeterminably darkening; on pores and tubes lilaceous pink, becoming drab, old specimens "vinaceous rufous" becoming "testaceous"; on context of stipe lilaceous pink, in age slowly to "dark vinaceous brown," middle portion more date brown. — **$FeSO_4$** very deep olive to black.

Habitat: On the naked or mossy ground and on mossy trunks in hammocks (low and high as well), more rarely in flatwoods and scrub, always in the neighborhood of either *Pinus palustris* or *P. taeda* though occasionally as far as 11 m. from the nearest pine tree, scattered or in small groups,

fruiting from May to September in north Florida, in central Florida until October.

Distribution: North and central Florida.

Material studied: **Fla.** Highlands Co., Highlands Hammock State Park, *R. Singer, F 478, F 478 a, etc.* (the **type** is *F 478*) (FH); Lake Co., Eustis, *R. Thaxter* (det. Singer) (FH); Levy Co., Gulf Hammock, *W. A. Murrill, F 18751* (FLAS); Alachua Co., Gainesville, *R. Singer, F 2164* (FH); near Dayville, *R. Singer, F 3035* (FH); Tung oil-mill on Newberry Road, *W. A. Murrill, F 17882* (FLAS); there were notes by W. A. Murrill at FLAS indicating the occurrence of what must be this form in Columbia Co.

Ssp. **hiemalis** Sing. ssp. nov.

Pileus between "wood brown" and "tawny olive" or "sayal brown" when young, later "ochraceous orange" and "pinkish buff" or "clay color" mixed with "sayal brown" and "bister," glabrous, smooth, naked, pulvinate, then convex with slightly depressed center, 50–63 mm. broad. — *Hymenophore* "antimony yellow" to "yellow ocher," or "primuline yellow" to "aniline yellow" with a shade of "honey yellow" to "olive ocher" when old, adnate, decurrent or more or less shallowly sinuate with a slight decurrent tooth, or plainly adnate; tubes 7–8 mm. long; pores concolorous or with some glands of the same color as these of the stipe, small (up to 0.5 mm. in diameter) with some larger ones intermixed (up to 1 mm.), not quite round; spore print between "ochraceous tawny" and "Isabella color." — *Stipe* pallid or whitish, becoming "light cinnamon drab," on the base "light salmon orange," eventually often with sordid shades or yellow portions, glandulose because of scattered to crowded glandular dots above and below the annulus which are concolorous with the pileus or paler, later becoming tawny or black (more often black), equal, solid, 30–35–(60) x 9–11–(13) mm.; mycelium salmon color; veil pallid, later becoming "citrin drab" to "deep olive" or gray, or some of these colors combined, or concolorous with the pileus, ruptured along a circular line near the apical surface of the stipe, and thus leaving an annular sheath on the stipe; annulus having the shape of a broad sheathing belt on the upper half of the stipe, tending to separate from the surface of the stipe at its lower white marginal rim, the outer (marginal) portion of the veil less persistent, eventually even the annulus which is fibrillose-membranaceous, and viscid to glutinous on its surface, collapsing or sliding downward, becoming yellow after freezing. — *Context* marbled "zinc orange" and "pinkish buff," or "buff yellow" near the surface of the pileus and sometimes also near the tubes, unchanging; odor like that of *S. punctipes* (agreeable), or none; taste mild or very slightly acid.

Spores 7.5–9.8–(12.3) x 2.7–3.5–(5) μ, ellipsoid-oblong to cylindric, smooth, pale melleous; *basidia* 20–26 x 6–7 μ, 4-spored; *cystidia* 34–90 x 4.7–11 μ, with castaneous or melleous incrustations, elongately clavate, not very numerous except at certain spots; *trama* and *pellicle* as in *ssp. aestivalis*.

Chemical reactions: **KOH** on surface of pileus plumbeous-gray; same reaction on tubes and context. — **NH_3** on surface of pileus almost negative;

on pores quickly "carrot red," then "vinaceous rufous," sometimes even "Hay's russet"; on context "carrot red" to "vinaceous rufous," sometimes even "Hay's russet," sometimes bright and lasting pinkish red in the base. — **NH_4OH** on surface of pileus slowly as with KOH; on pores as with NH_3, then slowly as with KOH; on context as on pores. — **H_2SO_4** on context deep reddish brown, subferruginous. — **$FeSO_4$** on context very deep olive to black (a very sensitive reaction).

Habitat: On soil under *Pinus palustris*, *P. taeda*, and *P. australis*, fruiting in Florida from October (north Florida) or November to January, farther north apparently during the fall months.

Distribution: From North Carolina to Florida. In Florida rather frequent in the north and probably also occurring in central Florida.

Material studied: **Fla.** Alachua Co., Gainesville, December and January 1942–1943, *R. Singer, F 1666* (**type**), *F 1666 a* (FH); Sugarfoot Hammock, January 1943 *R. Singer, F 1666 b* (FH); Orange Heights, November 1938, *W. A. Murrill, F 19400* (FLAS); Gainesville, *W. A. Murrill, 8778*; from schedulae (with the specimens removed) at FLAS by W. A. Murrill, it would seem that ssp. *hiemalis* also occurs in Marion Co.

The chemical differences of these two subspecies are similar to those between winter (below freezing) collections and summer collections of *Suilli* in general. The carrot red with ammonia is a reaction due to low temperatures, but there is, besides, a more purple reaction with alkali in the summer form. This and a slight difference in the color of the pileus are, in addition to the relative length of the stipe, the main distinguishing characters in all three cases of genuine or spurious seasonal dimorphism in *Suillus*. Despite careful and prolonged observation during two growing seasons, we were unable to ever find any alternation of summer and winter fruiting bodies at the same station, and, moreover, such an alternation could not even be considered possible during the time of our observation since the fruiting bodies of the summer form failed to show up even in the neighborhood of the places where the winter form had been collected. It must therefore be assumed that there exist, in this species, two parallel races, each adapted to one of the two different growing seasons of northern and central Florida. This biformity may have developed up to this point from a start similar to that found in *Flammulina velutipes* (Curt. *ex* Fr.) Karst. [*Myxocollybia velutipes* (Curtis *ex* Fr.) Sing.] whose seasonally dimorphous forms may be a more primitive stage of differentiation than what we have observed in *S. cothurnatus*. This is the first time that anything like the classical seasonally dimorphous races of R. Wettstein has been discovered in fungi.

It seems that Atkinson's *Boletus luteus* belongs partly to *S. subluteus*, and partly (*fig. 169*) to what in North Carolina takes the place of the winter form of *S. cothurnatus*. It may also be suspected that *S. cothurnatus*, together with similar forms, is hiding in Coker and Beers' description of *Boletus luteus*. Parts of the description and likewise their *pl. 5, fig. 2–3* suggest *S. cothurnatus*. I do not know whether in the Carolinas, so much farther north, with the biseasonal aspect of the mycoflora apparently in-

comparable with what is observed in Florida, or at least showing it in a much lesser degree, the distinction between ssp. *aestivalis* and ssp. *hiemalis* holds. It is quite possible that in another region another race occurs that shows less seasonal adaptation. It would be interesting to investigate further these things now that the distinction of *S. cothurnatus* from *S. luteus* has ceased to be a problem.

S. cothurnatus differs from *S. luteus* in having the whole context of an entirely different color. The difference is striking for anyone who knows the true *S. luteus*. Seasonal dimorphism has not been observed and obviously does not occur in *S. luteus*. Some smaller differences may be added but the easiest way to identify *S. cothurnatus* in the field is by the warm yellow context. I suspect that the forms associated with the series *Australes* of *Pinus* are always *S. cothurnatus*, and those associated with the pines of the series *Lariciones* are always *S. luteus*.

As for *S. subluteus*, commonly found under pines of the section *Cembra*, it is decidedly different from both *S. cothurnatus* and *S. luteus*. It is true that the glandulae of *S. luteus* are mostly supra-annular though occasionally also showing below the annulus, while *S. subluteus* and *S. cothurnatus* always have them both above and below the annulus, and more distinct at that. However, there is no need to stress this point since the main differences between all these species lie elsewhere. *S. subluteus* differs from *S. luteus* much more evidently in its more elongate stipe, its less distant veil, and its different colors. *S. subluteus* differs from *S. cothurnatus* in the shape of the annulus and the colors.

S. cothurnatus is edible, and as good as *S. luteus* though rarely abundant enough to be of much use.

9. **Suillus brevipes** (Peck) Kuntze, Rev. Gen. Plant. **3**[2]:535. 1898.

Boletus brevipes Peck, Ann. Rep. N.Y. State Mus. **38**:110. 1885.
Boletus viscosus Frost, Bull. Buffalo Soc. Nat. Sci. **2**:101. 1874.
Boletus pseudogranulatus Murr., Bull. Torr. Bot. Club **67**:63. 1940 (a variety).

Var. **typicus.**

Pileus in all colors occurring in *S. luteus*, viz. "fawn color," "Mikado brown," after cold rainy weather between "Sanford's brown" and "Mars orange" in some specimens, exposed portions soon bleaching to "cartridge buff," "cream buff," "chamois," "honey yellow," sometimes discolored to an indescribable drab (near "olive buff" or "deep olive buff"), often marbled in all these colors, or some of them, occasionally yellow showing through in frost-bitten specimens, with entire, rarely rimosely cracking, smooth, viscid pellicle which is easily entirely removable, glutinous in wet weather, naked and glabrous except for occasional appressed or fimbriate fibrils of the veil on the margin, often with narrowly sterile margin, with a dirty whitish covering all over in some of the veiled specimens, especially as long as they are young and grow in dry weather, convex, often somewhat depressed in the center, 40–105 mm. broad. — *Hymenophore* "baryta yellow," "straw yellow," "lemon yellow," eventually somewhat duller, adnate

or mostly very slightly sinuate near the stipe; tubes 4–6 mm. long, i.e. rather short; pores concolorous, finally becoming "deep colonial buff," small but of varying diameter, in average (2)–3 pores to a mm.; spore print between "ochraceous tawny" and "Isabella color." — *Stipe* white, becoming yellowish at apex and brownish at base when old, but always pure white all over when young, without glandulae, or often with very small concolorous or pallid to pale brown glandulae which are not readily visible to the naked eye and are limited to the upper third of the stipe, or sometimes to the middle portion, better visible on well-dried stipes, non-viscid, solid, cylindric or slightly ventricose, remarkably short, sometimes even shorter than thick, 8–30 x 10–24 mm.; veil inconstant and not persistent, never forming a true annulus and only rarely forming a narrow belt, but often found on the margin of the pileus, membranaceous-fibrillose, sordid drab to white or with these colors mixed, more distinctly visible in dry and warm weather. — *Context* pure and uniformly white in both pileus and stipe, later yellowish above the tubes, and in very old, especially frozen material, sometimes yellowish in most parts (reaching "yellow chrome"), soft and watery as in *S. luteus*; odor agreeable as in *S. luteus*, or none; taste mild and slightly acidulous.

Spores (6.7)–7.5–8.8–(11) x 2.7–(3) μ, pale melleous, subellipsoid-subfusoid to cylindric (more so from the profile), smooth, thin-walled; *basidia* 20–21 x 6–7 μ, 4-spored; *cystidia* 55–83 x 8–10.3 μ, numerous, strongly incrusted, only a few of them non-incrusted or little incrusted, clavate with a capitate apex, rarely subfusoid-subcylindric; *trama* truly bilateral; *pellicle* of the pileus consisting of an "ixotrichodermium"; stipe without dermatocystidia or with scattered ones but in those specimens with more or less distinct glandulae in dried condition, the latter are composed of fascicles of hymenium consisting of strongly incrusted clavate-capitate, or subfusoid, or clavate dermatocystidia, 27–67 x 8–14 μ.

Chemical reactions: **KOH** on surface of pileus, dark gray; on tubes, sordid gray to nearly "bone brown"; on white context, dirty lilac becoming more grayish and in older drier material lilac for a very long time and then drab; in the yellow context of the stipe, dirty lilac, becoming more grayish. — **NH_4OH** on the paler portions of the pellicle causing them to become darker, then "purplish vinaceous," darker portions slowly "purplish vinaceous"; on context of older drier material, lilac then blue. — **NH_3** on surface of pileus reacting as with NH_4OH; on white context, "alizarin pink" for a moment, then vanishing, in older and drier pilei "salmon pink"; on yellow portions of the context of the pileus, between "cadmium orange" and "orange rufous," becoming bluish-caesious; on tubes, "ochraceous salmon," in older drier material reacting as with the yellow context. — **H_2SO_4** on the pellicle nil; on the pores, rusty ochraceous. — **Methylparamidophenol** very pale grayish hyaline (almost negative), except for the zone above the tubes and across the apex of the stipe where a slow yellow reaction takes place, not becoming violet anywhere.

Habitat: In pine woods, under *Pinus taeda*, *P. australis* (in Florida; in

other regions with related species of pines), also in mixed woods under 2-needle-pines, gregarious, usually in large groups or rows; fruiting in Florida from October to May, farther north in fall.

Distribution: North America, most common in the southeastern states. In Florida mainly in the northern part, not observed in south Florida.

Material studied: **Fla.** Alachua Co., Gainesville, Dec.–Jan. 1942–43, *R. Singer, F 1646, F 1646 b, F 2044* (FH); *W. A. Murrill, F 18440 (Boletus granulatus)* (FLAS). — **N.Y.** Karner (**authentic** material of *Boletus viscosus* Frost) (NYS); also several collections of Peck (**authentic** material of *Boletus brevipes*) (NYS).

This species is very closely related to *S. granulatus* ssp. *Snellii*, and since material of this latter was the main source of information on *S. granulatus* in general available to Murrill, it is not surprising that he considered it as a synonym in *North American Flora*. However, when studied in Florida where *S. granulatus* ssp. *Snellii* and similar fungi except *S. brevipes* do not occur at all, the species seems to be quite constant in its characteristic features except for such definite varieties with longer or swollen stipe as shall be described below. These varieties show a limited though undeniable convergence toward *S. albidipes*. If it were not for some minor characters and the mycorrhizal association, these uncommon atypical forms of *S. brevipes* would seem to be indistinguishable from *S. albidipes*. This may lead to confusion in places where *S. brevipes*, *S. albidipes*, and *S. granulatus* ssp. *Snellii* occur simultaneously, and where mixed stands of conifers make the separation difficult. It is very probable that these seemingly convergent forms actually mark the evolutional starting point of the American group of species gravitating around *S. granulatus*. *S. brevipes*, then, would mark the stage of complete adaptation to 2-needle pines. Since *S. brevipes* and its varieties in Florida form a very definite group within the subsection *Angustiporini*, I do not combine it with *S. granulatus* as a subspecies, inasmuch as others may feel that not only *S. albidipes* and *S. brevipes* but also *S. granulatus* ssp. *Snellii* and ssp. *leptopus* (*S. Bellinii*) should all be treated as autonomous species, rather than as subspecies of *S. granulatus*. While no argument *pro* or *contra* is offered here, the author thinks it necessary to call the attention of the specialists to this very interesting though complicated problem in order to get more new facts from different regions. The necessity to do so will arise still more urgently when western collections are compared with material gathered in the East and South.

S. brevipes is, as also has been stated by Peck and others, a good edible species, providing large quantities of palatable food during the winter months for the few people who know it.

Var. **aestivalis** Sing. var. nov.

A typo differt stipite elongato et statura paulum minore. Sub *Pinibus taedis* in Florida Americae Borealis Junio–Augusto mensibus.

Differs by a longer stipe than the type variety, and thus approaches *S. albidipes* but easily distinguished by the smaller size, the almost non-

decurrent tubes, the white interior that becomes yellow with age (nowhere brownish red), and the mycorrhizal association with *Pinus taeda*. It is known only from the type locality in Gainesville, Alachua Co. Fla. where it grows infrequently in small groups. The microscopical and chemical characters are the same as in the type variety. Because of the longer stipe it corresponds to the seasonal dimorphous subspecies of *S. cothurnatus* and *S. hirtellus* but the difference seems to be less pronounced and less constant. We are still not entirely convinced that this is a summer race rather than a mere summer-adaptation alternating, on the same mycelium, with the winter fruiting bodies. As long as no more observations can be had, we shall have to term this a *varietas* in our sense (as a temporary nomenclatoral status).

Var. **pseudogranulatus** (Murr.) Sing. comb. nov.

Boletus pseudogranulatus Murr., Bull. Torr. Bot. Club **67**:63. 1940.

Pileus "avellaneous" with a slight drab or cinnamon tinge, or rather tending toward clay color or umber, with paler places, viscid when wet, moderately shining when dry, smooth and glabrous, but sometimes with easily separable inconspicuous sordid patches of a thin membranaceous deep dirty-gray veil on the margin which is very acute, strongly convex and usually remaining so in the middle while the marginal part becomes flattened, or becoming subplane all over, thick even for a bolete, 60–110 mm. broad. — *Hymenophore* between "empire yellow" and "picric yellow," somewhat irregular but not gyrose-merulioid, not quite readily separable from the context, adnate-decurrent, or decurrent and mostly continuing on the apex of the stipe as an indistinct narrow reticulated belt; tubes 4.5 mm. long in quite adult specimens, i.e. rather short; pores concolorous, small (about 2 to a mm.). — *Stipe* initially white but soon becoming "lemon chrome" and "light cadmium" at places and eventually entirely yellow, smooth or rarely very indistinctly rugulose near the base, glabrous or with very small, not very distinct pallid to blackish glandular dots as in *S. brevipes* var. *typicus* but often, at least on one side of the stipe, connected by very fine lines, and thus forming a network that may extend over a large portion of the stipe, or be confined to the apex, avelate or with a narrow, indistinct, soon disappearing annular belt which is deep dirty-gray, with swollen ventricose lower half which may again be tapering toward the very base, 30–60 x 26–40 mm. (near the middle or base), 17–24 mm. at the apex, solid; mycelium yellowish or yellowish white. — *Context* white, yellow in the peripheral parts of the stipe and in the base, often also toward the tubes, very thick and solid-fleshy in the pileus except for the swollen part of the stipe where it may be soft and spongy; odor as in *S. luteus*; taste mild or slightly acidulous.

Spores (6.7)–7.5–9.5–(11) x 2.7–(3.3) μ, in shape and color similar to those of var. *typicus*; *basidia* as in var. *typicus*; *cystidia* 30–65 x 7.5–10.5 μ, numerous, strongly fulvous-castaneous or melleous from a resinous in-

crustation, oval or clavate above, more rarely fusoid or ampullaceous, with thin lower part.

Chemical reactions: **KOH** on context and surface of pileus, drab; on context of stipe, grayish green becoming black; on pores, deep grayish brown. — **NH_3** and **NH_4OH** on the surface of the pileus, slate gray; on context of pileus, rosy pinkish then becoming slate gray; on pores and tubes, "vinaceous rufous," then becoming grayish green, and same colors seen in the cortex of the stipe. — **H_2SO_4** on the tubes a similar reaction as with NH_3. — **Aniline** negative. — **Formol** negative. **Methylparamidophenol** negative. Note: these reactions were obtained with quite mature fruiting bodies in cold weather.

Habitat: In dense hammocks, under or near *Pinus palustris*, *P. taeda*, or *P. australis*, solitary, fruiting from October to April.

Distribution: Known only from Alachua Co., Fla.

Material studied: **Fla. Type** (FLAS); Gainesville, *R. Singer, F 1704* (FH); *F 1877* (FH).

This species has not a distinctly elongate but rather a ventricose or inversely claviform stipe. It is much more variable than may be assumed from Murrill's description. The thicker stipe with decurrent tubes distinguishes it from the type. The reticulation stressed by Murrill is an inconstant character. In only one carpophore out of all I have seen, do I find a reticulation worth recording. The veil cannot serve as a distinguishing character since the same kind of veil is observed also in a certain percentage of fruiting bodies of the type variety, but these fruiting bodies do not differ from the avelate ones in any other way. Var. *pseudogranulatus* seems to be an aberration due to peculiarities of the habitat. It occurs in moister soil of hammocks where the carpophores are less exposed to the rain. Whether this is just a *forma*, or a constant race, cannot be decided immediately.

EXTRALIMITAL SPECIES

Suillus subluteus (Peck) Snell *apud* Slipp & Snell, Lloydia **7**:34. 1944.
Boletus subluteus Peck, Bull. N.Y. State Mus. **1**:62. 1887.

Since this species has been confused with *S. luteus* as well as with the Floridan *S. cothurnatus*, I think it is necessary to give a complete description of *S. subluteus*, based on collections made by this writer in the Huntington Wild Life Forest, Newcomb, N. Y. (FH, NYS) which were compared with the type of *S. subluteus* (NYS).

Pileus more or less "chamois" (colored somewhat like the European *S. flavidus*), but sometimes more reddish than "chamois," sometimes more olive, glutinous when wet, often slightly squamulose with indistinct, appressed squamulae, convex, 57–63 mm. broad. — *Hymenophore* various shades of yellow with an olivaceous shade in age, adnate to slightly decurrent; tubes medium long; pores decidedly smaller than 1 mm. in diameter, only in large, old specimens reaching 1 mm., somewhat angular, be-

coming somewhat sordid on pressure, somewhat glandular-dotted; spore print between "ochraceous tawny" and "Isabella color." — *Stipe* concolorous with the pores, more pallid near the base, beset with light brown, later, especially below, often with dark brown to almost black glandulae above and below the annulus, with watery, colorless, or watery-yellow droplets distilled from the glandular dots on the pores next to the stipe and on the apex of the stipe, annulate, solid, equal or slightly thickened downward, slender as compared with the usual shape of the stipes of *S. luteus*, about 60 x 9 mm.; mycelium sordid-grayish; annulus pallid, appressed or somewhat distant in young specimens, not conspicuously broad-sheathing, and soon collapsing into a mere slimy belt, apical but sometimes sliding down to the middle, membranaceous but very glutinous when wet and eventually sordid or concolorous with the remaining surface of the stipe. — *Context* white, very slightly and slowly turning sordid when exposed, in the stipe more yellowish when bruised; odor like that of *S. punctipes* but weaker; taste mild, slightly acidulous.

Spores 9–10.7–(11) x 3.3–3.8 μ, mostly 9.5 x 3.5 μ, rather pale melleous, smooth; *cystidia* 38–120 x 5.5–7.5 μ, cylindric, obtuse at the apex, or clavate, almost constantly incrusted with a brown, resinous crust or granules, *glandular dots* consisting exclusively of (20)–70–125 x (3.5)–7–9.5 μ large, narrowly clavate, rarely fusoid and then often 6.5 μ broad, incrusted dermatocystidia; *hyphae* without clamp connections.

Chemical reactions: **KOH** on surface of pileus, dark sordid gray; on pores, dark reddish brown. — **NH_3** and **NH_4OH** on surface of pileus, reddish brown; **NH_3** on the context of the pileus, salmon pink; **NH_4OH** on the context of the pileus, blue; on the pores, dark gray. — **Methylparamidophenol** negative.

Habitat: With *Pinus strobus* (and probably with other 5-needle pines) in woods, often together with *S. granulatus* ssp. *Snellii*.

Distribution: Eastern States of the U.S.A., not reaching Florida in the south; the western limits of the species have not been established.

The spores which are larger than those of *S. cothurnatus* and *S. luteus*, provide a good character to distinguish poor specimens or dried material of *S. subluteus* from *S. luteus* and *S. cothurnatus*. The chemical characters also seem to be different in these species (see also observations under *S. cothurnatus*).

Suillus luteus (L. *ex* Fr.) S. F. Gray, Nat. Arr. Brit. Pl. **1**:646. 1821.

Boletus luteus Linné *ex* Fr., Syst. Mycol. **1**:386. 1821.
Ixocomus luteus Quél., Flor. Mycol. p. 414. 1888.
Cricunopus luteus Karst., Rev. Mycol. **3**:16. 1881.

The description and figures given by Kallenbach, Pilze Mitteleuropas **1**(8):45, *pl. 19*. 1928, should be compared with the foregoing descriptions of *S. subluteus* and *S. cothurnatus*. In order to make this comparison complete, I want to add some data on *S. luteus*, either not contained in Kallenbach's account or mentioned there in a different manner:

Spores in a very fresh print "ochraceous tawny," under the microscope (6.8)–7.5–9–(10) x 2.8–3.3 μ, pale melleous, smooth, ellipsoid-subfusiform to cylindric. — **KOH** on surface and context of pileus, "slate olive" to dark dirty-gray; on the context, occasionally reddish at first; on the pores, "bone brown," or reddish to brownish red and eventually becoming "bone brown," at times passing through a lilac phase before becoming brown. — **NH_3** on surface of pileus, negative to very pale pink; on context of pileus (where yellow), "salmon buff," eventually with lilac shades; on pores and tubes, pale reddish to brownish pink or orange-tawny. — **NH_4OH** on surface of pileus, little reaction, or slowly dark gray; on context of pileus, "slate olive" (where it had been yellow). — **H_2SO_4** on the yellow context of the pileus, "primulin yellow"; on pores, "ochraceous orange"; on surface of pileus, negative.

Habitat: Under *Pinus silvestris*, *P. montana*, *P. nigra*, *P. resinosa* (also reported with *P. pinaster* by Kallenbach but this seems doubtful; in experiments, forming mycorrhiza even with *Picea* and *Larix*), i.e. in nature always with pines of the section *Lariciones*.

Due to the erroneous identification of *S. subluteus* and *S. cothurnatus* as *S. luteus*, the author was for a while doubtful as to whether the true *S. luteus* occurs in America at all. However, a large collection of excellent fresh material growing under *Pinus resinosa* (coll. P. Gast, September 1944 in the Harvard Forest, Petersham, Mass.) proved the fact that a species entirely identical with the European *S. luteus* occurs in this country. It is now difficult to say whether this was originally imported with *Pinus silvestris* and then spread, or — more probably — if it is native in North America. It does not reach Florida.

Suillus placidus (Bon.) Sing., Farlowia **2**:42–43. 1945.

Boletus placidus Bon., Mohl's Botan. Zeitschr. **19**:204. 1861.
Boletus albus Peck, Rep. N.Y. State Cab. **23**:130. 1873.[12]

As for the discussion of this species see Singer, *l.c.* 1938, and *l.c.* 1945. The types of Peck's have been compared with material collected by this writer in New York State. *B. albus* and *B. placidus* are most certainly identical.

I do not think that *S. placidus* occurs in Florida. I have not collected white *Suilli* in Florida at all. W. A. Murrill collected a specimen of what he calls *Boletus granulatus* (in his sense a collective species), adding, on the label (*F 16407*, FLAS) "white form." It was more slender-stemmed than the usual *S. brevipes* but this would not mean much since it was collected in summer when the slender-stemmed summer form of *S. brevipes* is found. The glandulae are not too clearly visible. Schematically, this specimen would have to be determined as *S. placidus* but it may also be a white form of *S. brevipes* var. *aestivalis*, or an exannulate form of **S. acidus** (Peck) comb. nov. (*Boletus acidus* Peck).

[12] For a complete list of synonyms see Singer, Rev. de Mycol. **3**:48. 1938.

Suillus granulatus (L. *ex* Fr.) Kuntze, Rev. Gen. Plant. **3**²:535. 1898.

The European type (ssp. *typicus*), the American (ssp. *Snellii*), and the Mediterranean (ssp. *leptopus*) race have been discussed in Farlowia **2**:41–45. 1945. When studying the western collections of *Suilli*, the author came across an abundant collection of what is easily recognized as *S. granulatus*, but the determination of the subspecies causes difficulties. I cannot, without extensive study of fresh material, indicate whether this Idaho subspecies is identical with any known subspecies or represents an allied subspecies, but it probably is not ssp. *Snellii*. This partly explains the fact that Slipp and Snell find slight modifications in size and veil of Idaho specimens depending on whether the plants occur with *Pinus monticola* (sect. *Cembrae*) or *P. contorta*. The specimen shown in the illustration (Lloydia **7**:41, *pl. 4, fig. A*. 1944) would suggest *S. brevipes* by its habit but it probably is the *Pinus contorta* form of *S. granulatus*. Good *separate* descriptions of these collections may help solve this problem.

Suillus albidipes (Peck) Sing., Farlowia **2**:45. 1945.

Boletus granulatus var. *albidipes* Peck, Rep. N.Y. State Mus. **54**(1):168. 1901.
Boletus albidipes Peck, Rep. N.Y. State Mus. **65**:22. 1912.

This little known species is about intermediate between *S. brevipes* and *S. granulatus* ssp. *Snellii*. Since the summer form of *S. brevipes* or *S. brevipes* var. *pseudogranulatus* may be confused with *S. albidipes*, and also because of the lack of adequate descriptions of *S. albidipes*, we include here a description of it, obtained from material collected by this writer near Newcomb, N. Y. (FH) and compared with the type (NYS).

Pileus "cinnamon rufous," somewhat deeper colored when young, slightly tending toward "zinc orange," with the yellow of the flesh showing through the pellicle of very old and watery specimens, darker and paler spots sometimes tessellately alternating, usually slightly rivulose under the viscose surface, or areolate when old, pallescent from the middle outward in many specimens, the margin in very many of the young specimens with a white or pallid velutinous or fibrillose-tomentose band from an indistinct veil, convex, obtuse, 40–105 mm. broad. — *Hymenophore* flesh-whitish, then yellow as in *S. granulatus* ssp. *Snellii*, adnate-decurrent to strongly decurrent; tubes as long and the concolorous pores as wide as in *S. granulatus* ssp. *Snellii*; spore print between "ochraceous tawny" and "Isabella color" (nearer to the latter). — *Stipe* pure white becoming somewhat lemon-yellow in the upper fourth to two thirds when old or in cold weather, usually stained with tan color in the middle, yellowish fibrillose at the base, indistinctly glandulose all over or with small scattered white, later pale brown glandulae at the apex (upper fourth to half), otherwise glabrous and smooth, non-viscid, solid, often becoming stuffed, cylindric or clavate (tapering upward), or tapering downward, or ventricose, straight or curved, 50–115 x 8–28 mm.; mycelium white. — *Context* white, later reddish or brownish (reminding one of *Amanita rubescens* in this regard) in the stipe, especially in the middle of the stipe, in the apex of the stipe rather becoming

bright lemon yellow than reddish, and also somewhat lemon yellow toward the tubes; odor as in *S. luteus*, but very slight; taste mild to slightly acidulous.

Spores 6.8–9.2 x 2.7–3.2 μ, mostly 7.8–8.5 x 3 μ, pale melleous, smooth, cylindric, fusoid-cylindric, or fusoid-ellipsoid; *basidia* about 20 x 5 μ, 4-spored; *cystidia* either hyaline and scattered, or more or less incrusted and in fascicles or scattered, cylindric-clavate or broadly clavate, their wall slightly thicker than the wall of the basidia, 42–72 x 6.5–11.5 μ; *trama* and *pellicle* as well as glandulae as in *S. brevipes*.

Chemical reactions: **KOH** on surface and context of pileus, dirty grayish, *not* violet; on pores, deep dirty fuscous, becoming almost black, blackish fuscous. — **NH_3** and **NH_4OH** on surface of pileus, more grayish; on context of pileus, pink then lilac ("pale brownish vinaceous"); on context of stipe, negative, only lemon-yellow places becoming deep orange-brown-rufous; on tubes, orange-ferruginous.

Habitat: In open coniferous and mixed woods under or near *Pinus strobus* (sect. *Cembrae*), but occasionally, in regions where white pine is common, also growing with *Abies balsamea*.

Distribution: From Massachusetts to New York, south apparently to North Carolina, but western limits unknown.

This differs from *S. brevipes* in the elongate stipe, the reddish tones in the context, and the habitat; from *S. granulatus* in the reduced glandulosity of the stipe, a slight difference in the chemical reactions, and the reddish tones in the context. It may eventually be reduced to the status of a subspecies of the latter.

Subsect. **Hirtellini** Sing. subsect. nov.

Sporis in cumulo saturate brunneo-olivaceis; poris circa 1 mm. amplis, interdum paulum amplioribus vel angustioribus; carne pilei ammoniaci ope vix vel tardive reagente (grisente vel violascente); pileo innate fibrilloso in juventute vel fibrilloso-squamuloso-hirtello.

Characters of the subsection: see key (p. 259) and the above Latin diagnosis. Type species *Suillus hirtellus* (Peck) Kuntze (*Boletus hirtellus* Peck).

KEY TO THE SPECIES

A. Context unchanging or at least not becoming blue on exposure; stipe only very slightly and gradually tapering toward the apex or almost perfectly equal.

B. Stipe strongly thickened toward the base; pores brownish to brownish-olive, never clear yellow; glandulae crowded, often running into each other and making the stipe sticky; numerous non-incrusted fusoid cystidia present on the pores; spores (7.8)–8.8–11.5 x 3–3.7 μ; color of the pileus often about "Mars yellow"; mycelium white; ammonia (also vapors) on the surface of the pileus definitely negative. *S. punctipes*

B. Stipe slightly if at all thickened toward the base; pores from the early immature to the final overmature stage showing a clear yellow, or more pinkish-ocher in youth and more yellowish-olive in age; glandulae though distinct and numerous not really crowded and not forming sticky patches; non-

incrusted cystidia infrequent, fusoid cystidia exceptional, or wanting; spores (6.8)–7.5–10.2 x 3–3.5 μ; color of the pileus never "Mars yellow"; mycelium not always white; ammonia (vapors) on the center of the pileus after long exposure "Persian lilac," on the margin "acajou red"; ammonia water lilac, then carmine, then amethyst color around an eventually "cinnamon buff" spot. 10. *S. hirtellus*

A. Context more or less bluing; stipe more or less thickened toward the base.

C. Pileus and stipe golden yellow, then sulphur yellow to yellowish cream; mycelium white, "in seral association in the *Thuja-Tsuga*-zone" in Idaho. *S. hirtellus var. mutans*

C. Pileus ocher brownish to orange brownish with darker squamulae; mycelium pink; in *Larix-Pinus-Picea*-stands of the northern slopes of the Altai Mts. associated with *Pinus sibirica*. *S. cembrae*

10. **Suillus hirtellus** (Peck) Kuntze, Rev. Gen. Plant. **3**[2]:535. 1898.

Boletus hirtellus Peck, Bull. N.Y. State Mus. **2**(8):94. 1889.
Ixocomus hirtellus Sing., Ann. Mycol. **40**:30. 1942.
Rostkovites hirtellus Murr., Mycologia **1**:14. 1909.
Boletus hirtellus var. *siccipes* Coker & Beers, Boletaceae, p. 83. 1943.

Ssp. **cheimonophilus** Sing. ssp. nov.

Mycelio plerumque manifeste albido, carpophoro majore, stipite breviore latitudine pilei, tubulis circum stipitem raro distincte depressis; sporis saepe elongatis, tenuibus, plus minusve cylindricis; forma hiemalis.

Pileus "barium yellow" to "pinard yellow" with subconcolorous or somewhat darker innate fibrils which form subappressed but hirtose squamulae on the disk, dry in dry weather, decidedly viscid in wet weather, occasionally showing a grayish band around the extreme margin (veil), convex, becoming subplane, 50–90 mm. broad. — *Hymenophore* "wax yellow" to "olive lake," adnate to slightly depressed, not decurrent; tubes moderately long; pores concolorous but often with some brownish glandulae, medium wide (around 1 mm. in diameter), not exuding drops unless diseased; spore print rather deep olive. — *Stipe* yellow, pallid toward the base, beset with numerous pale brown, then testaceous-chocolate, eventually blackish glandulae over its entire length, solid, equal or at least equal in its upper two thirds, and then the base slightly thickened and again acuminate below, 40–70 x 5–20 mm., mostly 45–60 x 5–20 mm.; veil none on the stipe; mycelium mostly whitish. — *Context* pale yellow, unchanging; odor none; taste mild.

Spores 8–13.5 x (2.5)–3–3.3–(3.7) μ, melleous, smooth, cylindric or subfusoid-cylindric, rarely subellipsoid with suprahilar depression, or without depression; *basidia* and *cystidia* as in ssp. *thermophilus*; *trama* and *glandulae* not studied.

Chemical reactions: **KOH** on surface of pileus and stipe and on the pores and context, "bay" but somewhat deeper. — **NH_3** and **NH_4OH** on surface of pileus, negative for a long time, then assuming a vinaceous hue, then "cinnamon buff"; on pores, more sordid grayish olive, then becoming deep olive gray with a cinnamon ring; on context, an undefinable grayish tinge, then becoming pallid sordid brown.

Habitat: On sandy soil under pines, in Florida under *Pinus palustris*, *P. australis*, and *P. taeda*, usually solitary, or in small groups, fruiting in Florida in December and January.

Distribution: Florida (if the northern form is included, it is distributed from New York to Florida with the western limits unknown).

Material studied: **Fla.** Alachua Co., Newnan's Lake, Jan. 30, 1943, *R. Singer, F 1772* (FH); Magnesia Springs, Jan. 5, 1941, *G. F. Weber, (indet.) F 19826* (FLAS).

Ssp. **thermophilus** Sing. ssp. nov. TEXT-FIGURE 1.

Mycelio plerumque manifeste roseolo; carpophoro minore; stipite longiore latitudine pilei; tubulis circum stipitem plerumque distincte depressis; sporis forma sua haud distinctis; forma aestivalis thermophila.

Pileus initially cinnamon, soon becoming "baryta yellow," somewhat "maize yellow" on the disc, then "Martius yellow" or "sulphur yellow," or "light Chalcedony yellow," subviscid, innately fibrillose and minutely hirtose, the margin initially covered with cobweb-like to woolly remnants of the veil which in the primordia continues into an indistinct, glutinous, hyaline veil that disappears before full maturity, convex, soon flat around the umbo, but sometimes without an umbo (subumbonate or obtuse), 38–58 mm. broad. — *Hymenophore* between "deep colonial buff" and "olive ocher," depressed around the stipe; tubes 5–8 mm. long; pores initially "capucine buff," then "ochraceous buff," then "barium yellow," then "light ochraceous buff," and eventually between "deep colonial buff" and "dark olive buff," or "sulphine yellow," small (2 to a mm.) to medium (7 to 5 mm. tangentially, or 4 to 5 mm. radially), up to 1 mm. in diameter; spore print deep olivaceous. — *Stipe* concolorous, the brightest portions about "primuline yellow," beset with glandular dots which are sparse to very numerous, initially white or cinnamon, later concolorous with the remaining surface of the stipe, or whitish, then becoming carmine red, brownish red or indefinitely remaining concolorous, the upper part of the stipe and also sometimes the pores guttulate (droplets consisting of a whitish, rarely avellaneous latex), entirely solid, cylindric (after having been thinner at the apex in very young stages) to subequal, or with a root-like tapering base, 50–60 x 6–9 mm.; mycelium mostly salmon color; veil none. — *Context* yellow, unchanging; odor none, or very slight, like that of *S. luteus*; taste mild.

Spores (6.8)–7.5–10.2 x 3–3.2 μ, brownish melleous, some pale melleous, smooth, fusoid to ellipsoid, in profile cylindric to fusoid; *basidia* 26 x 7 μ, 4-spored; *cystidia* 37–71 x 5.3–16 μ, with about 0.5 μ thick walls (the often strongly developed resinous incrustation not included), most of them colored because of the incrustation, few hyaline, elongate-clavate, in fascicles; *dermatocystidia* of the glandulae of the stipe of one type only, viz. the incrusted, clavate (*Suillus*-) type, 17–77 x 6–9.5 μ; hyphae without clamp connections.

Chemical reactions: **KOH** on surface of pileus, deep brownish yellow or lilaceous brown; on pores, dirty brown; on context, various shades of

brown. — **NH_3** little reaction immediately but if exposed long enough, the disc of the pileus becomes "Persian lilac," and the margin "acajou red"; on pores, slowly drab; on context, negative or similar to the reaction on the surface of the pileus. — **NH_4OH** on surface of pileus, lilac, then carmine, then amethyst color, then fading; on the context of the stipe, almost negative, or slowly sordid; in the base of the stipe, rapidly drab. — **$FeSO_4$** on the context, slowly olivaceous yellow.

Habitat: In mixed stands of low hammock and in flatwoods under *Pinus palustris* in small groups, fruiting from June to September, or perhaps October.

TEXT-FIGURE 1. *Suillus hirtellus* (Peck) Kuntze ssp. *thermophilus* Singer. Fresh specimens from Highlands Hammock State Park, Florida after prolonged exposure to ammonia vapors to bring out the hirtose character of the pileus. x ¾.

Distribution: From Georgia to south Florida (not in the tropical zone).

Material studied: **Fla.** Highlands Co., Highlands Hammock State Park, Aug.–Sept. 1942, *R. Singer, F 543* (**type**) (FH); *F 543 a, F 543 b* (FH); Alachua Co., Gainesville, *W. A. Murrill,* (as *B. granulatus*) *F 16526* (FLAS). — **Ga.** Vicinity of Talullah Falls, north bank of river above bridge, Sept. 1901, *A. B. Seymour & W. L. Moss* (det. W. H. Snell as *B. hirtellus*) (FH); Fern Valley, Sept. 1901 (FH); Fern Brook and Bad Branch, Sept. 1901 (FH).

I am at present not in a position to decide whether the northern form, *i.e.* the type form, belongs to any of these subspecies or constitutes a subspecies by itself. From the specimens I have seen, and from the best descriptions available, I would guess that it belongs rather to ssp. *cheimo-*

nophilus. More phenological observations, however, will have to prove this point. It is possible that the northern form is unadapted to any special season and shows some distinguishing character or characters that would make it advisable to separate it as ssp. *typicus*.

We have examined authentic material of *Boletus hirtellus* var. *siccipes* Coker & Beers, *l.c.* The differences between this and the Albany specimens are so slight as to be considered negligible.

EXTRALIMITAL SPECIES

Suillus hirtellus var. **mutans** (Peck *ex* Snell) Snell *apud* Slipp & Snell, Lloydia **7**:23. 1944.

Boletus hirtellus var. *mutans* Peck *ex* Snell, Mycologia **33**:26. 1941.
Boletus tomentosus Kauffman, Pap. Mich. Acad. Sci., Arts & Lett. **1**:117. 1921, *non* Krombh. Nat. Abb. Schw. **5**, *pl. 36, fig. 19–20*. 1836 (year uncertain), *nom. nudum*; *nec Boletus tomentosus* Raddi *ex* Sacc. Syll. **23**:346. 1925.

I have seen only Henderson's specimens (NYS) of Peck's unpublished variety which may well be an autonomous species or a geographic race (subspecies) of *S. hirtellus*. If recognized as a species, it should be known under the specific epithet used by Kauffman, since the figures in Krombholz do not provide essential characters and do not give analyses as would be necessary to really understand this species. Art. 44 (3) of the International Rules is therefore not applicable in this case, and is, for that matter, very rarely applicable at all in groups where the color of the spores and their shape, the presence or absence of clamp-connections, the structure of the trama, the viscidity of the pileus or stipe etc. are essential characters while the characters shown in these early pictures are "essential" (if the meaning of the word is stressed) only if the painting is executed and reproduced so well as to leave no doubt about the identity of the fungus. This is not the case with *B. tomentosus* Krombh. The description given by that author later under another name, combines two tentative "new species" and is, consequently, useless as a descriptive basis for *B. tomentosus*. *B. tomentosus* Raddi is pre-Friesian, and was validated by Saccardo four years after Kauffman. The only way of ruling out Kauffman's species is by proving it to be a synonym (of *S. hirtellus* or a subdivision of it, or perhaps of *Rostkovites californica*), not a homonym.

Suillus cembrae (Sing.) Sing. comb. nov.

Ixocomus cembrae Sing., Rev. de Mycol. **3**:49. 1938.

Described from the Altai Mts. in Siberia, this is an independent species, close to *S. punctipes* (Peck) Sing.

Suillus punctipes (Peck) Sing. comb. nov.

Boletus punctipes Ann. Rep. N.Y. State Mus. **32**:32. 1880.
Ixocomus punctipes Sing., Ann. Mycol. **40**:30. 1942.

The data obtained through study of fresh and dried material in New York State show that this species, observed under *Pinus strobus* by this

author, has white mycelium (not pink as *S. cembrae*), and that the context remains unchanged when broken. This, coupled with the difference in the mycorrhiza-host, indicates that these specimens are different. The chemical reactions of the New York material were: **KOH** on surface of pileus, brown; on context of pileus, immediately sordid lilac, then lilaceous brown; **NH_3** on surface of context of all parts, negative; **NH_4OH** on surface of pileus, negative; on context of pileus, slowly pale and sordid lilaceous; **$FeSO_4$** on context of pileus, pale gray. — The spores are subfusoid-subelliptical in frontal view, subfusoid in profile, melleous, smooth, (7.8)–8.8–11.5 x 3–3.7 μ; basidia 20–28 x 6.5–7 μ, 4-spored; cystidia broadly clavate to mostly elongate-clavate, or fusoid, either non-incrusted or more or less strongly incrusted, very numerous, especially near the pores, the walls moderately (0.5 μ) thick, 30–70 x 4.5–10.5 μ, the incrusted ones more often clavate than fusoid and the non-incrusted ones more often fusoid. — This species is distributed in the northeastern States reaching south as far as North Carolina with the western limits unknown.

Sect. **Bovini** Sing., Rev. de Mycol. **3**:38. 1938.

Characters of the section: see key, p. 259. Type species: *S. bovinus* (L. *ex* Fr.) Kuntze, Rev. Gen. Plant. 3^2:535. 1898 belonging in subsect. *Euryporini* Sing. *l.c.*, p. 53. Another species, *S. variegatus* (Sw. *ex* Fr.) Kuntze, *l.c.* is the type of subsection *Stenosporini* Sing. *l.c.* None of these occurs in Florida, and even their occurrence in North America is, though claimed, not quite certain.

Sect. **Piperati** Sing., Rev. de Mycol. **3**:38. 1938.

This differs from the preceding section mainly in having dull red or pink tubes. The viscidity of the pileus is not always as strongly developed as in the other sections, but the hyphae of the cuticle are remarkably loosely arranged and imbedded in a gelatinous mass. While in other sections the color of the mycelium usually ranges from white to dirty drab or from white to pink, it tends to yellow in the *Piperati*. Two species are known, the type species *S. piperatus* (Bull. *ex* Fr.) Kuntze, Rev. Gen. Plant. 3^2:535. 1898 with its variety *amarellus* (Quél.) Sing. and *S. rubinellus* (Peck) Sing. None of these has ever been found in Florida.

SPECIES INCOMPLETELY KNOWN

Rostkovites californica Murr., *Boletinus flavoluteus* Snell, *B. glandulosus* Peck are some species apparently belonging in *Suillus* but not well enough known to this author. They have no bearing on Florida species, nor, like any other species that may enter into this category, do they have outstanding taxonomic significance.

SPECIES EXCLUDENDAE

Suillus castaneus (Bull. *ex* Fr.) Poir. *in* Lam. *ex* Karst.
Suillus cyanescens (Bull. *ex* Fr.) Poir. *in* Lam. *ex* Karst.

Suillus subalbellus (Murr.) Sacc. & Trott.

Suillus atroviolaceus Hoehn.

All these species belong in *Gyroporus*, not in *Suillus* S. F. Gray.

Suillus jamaicensis (Murr.) Sacc. & Trott. is not a *Suillus* in our sense, nor is it a *Gyroporus*, cf. p. 240.

Suillus hygrophanus Rostr. can be almost anything. No specimens seen.

Suillus cantharelloides (Jacobasch) Sacc. & Syd. is not a bolete.

Suillus Maxonii (Murr.) Sacc. & Syd.

This is a polypore, and, as the type (NY) shows, belongs in the genus *Polyporus sensu str.* The spores are hyaline, thin-walled, cylindric or cylindric-fusoid, 11–12 x 5 μ; hyphae of the tube-trama interwoven-subparallel, trama not bilateral but subregular, walls thin, clamp connections numerous. It is described from Costa Rica, and should be known as **Polyporus Maxonii** (Murr.) Sing. comb. nov.

Kuntze, Revisio Generum Plantarum **3**^{2}:535–536. 1898, amused himself by transferring practically all known species of *Boletus* which he copied from Saccardo, to *Suillus* because of priority or what he used to call so. Personally, he has never seen any of them except perhaps *Boletus edulis* in his kitchen.

Subfam. **Xerocomoideae** Sing. subfam. nov.

Hyphis haud fibuligeris vel raro paucas fibulas gerentibus; sporis fusoideo-subcylindraceis, olivaceo-brunneis in cumulo (numquam roseolis nec flavis nec ferrugineis); pileo subtomentoso vel tomentoso jove sicco, saepe viscidulo jove pluvio; hymenophoro lamelloso interstitiis venosis vel tubuloso et tunc poris plerumque amplis, irregularibus, compositis praedito, sed nunquam typice boletinoideo, adnato vel decurrente; cystidiis hyalinis vel melleo-incrustatis vel melleo-tinctis; tramate hymenophorali subbilateralisubregulari (typi "phylloporoidei") strato laterali vix laxiore quam mediostratum leniterque tantum divergente; stipite solido, cylindraceo vel subcylindraceo, rarius ventricoso-subbulboso, glandulis veloque carente. Habitatio: Ad terram et ad lignum sub variis arboribus.

Characters of the subfamily: see key p. 227 and the above Latin diagnosis. Type genus: *Xerocomus* Quél.

Phylloporus Quél., Flor. Mycol., p. 409. 1888.

This genus has all the characters of the first section of the following genus of this subfamily except for the different configuration of the hymenophore. This is the only genus of the Boletaceae with gills instead of tubes. It can, however, be distinguished from all gill fungi by its characteristic bright and deep blue to green-blue reaction with ammonia on the surface of the pileus and the structure of the young gill trama. The hyphae are usually clampless but in some specimens some rare clamps can be observed if carefully and patiently searched for. The type species is *P. Pelletieri* (Lév. *apud* Cr.) Quél. which in its turn is the same as *P. rhodoxanthus* (Schw.) Bres. ssp. *europaeus* Sing. Another subspecies of this species occurs in Florida.

11. **Phylloporus rhodoxanthus** (Schw.) Bres., Fung. Trid. **2**:95. 1900.

Agaricus rhodoxanthus Schwein., Schr. Naturf. Ges. Leipzig 1822, **1**:83. 1822.
Paxillus flavidus Berk., Lond. Jour. Bot. **6**:315. 1847.
Paxillus pinguis Hook. fil. *apud* Berk., Hook. Journ. Bot. **3**:41. 1851.
Agaricus Pelletieri Lév. *apud* Crouan, Flor. d. Finistère, p. 81. 1867. (=ssp. *europaeus* Sing.)
Agaricus paradoxus Kalchbr., Icon. Fung., p. 27. 1873 (=ssp. *europaeus* Sing.)
Paxillus paradoxus Cooke, Grevillea **5**:6. 1876 (=ssp. *europaeus* Sing.).
Clitocybe Pelletieri Gill., Champ. Fr., p. 170. 1878 (=ssp. *europaeus* Sing.)
Gomphidius rhodoxanthus Sacc., Syll. **5**:1139. 1887.
Flammula rhodoxanthus (*sic*) Lloyd, Myc. Not. **1**(no. 3):17. 1899.
Paxillus sulcatus Pat., Bull. Soc. Myc. Fr. **5**:7. 1909 (=ssp. *americanus* Sing.?).
Paxillus rhodoxanthus Ricken, Blätterp. **1**:95. 1911 (formally ssp. *americanus*)
Phylloporus bogoriensis Hoehn., Fragm. Mycol. **16**(838):41. 1914 (=ssp. *bogoriensis* Sing.)
Paxillus Pelletieri Velen., Cesk. Houby **2**:356. 1920 (=ssp. *europaeus* Sing.)
Phylloporus sulcatus Gilbert, Bolets, p. 88. 1931 (=ssp. *americanus* Sing.?)
Phylloporus paradoxus Cleland, Toadst. & Mushr. **1**:178. 1934 (formally=ssp. *europaeus*)
Gomphidius foliiporus Murr., Mycologia **35**:432. 1943 (=ssp. *foliiporus* Sing.)
?*Agaricus Tammii* Fr., Öfvers. K. Vetensk.-Akad. Förh. **18**(1):24. 1861.
?*Gymnocybe Tammii* Karst., Hattsw., p. 412. 1879.
?*Paxillus Tammii* Pat., Tab. Anal. Fasc. **4**:161. 1885 (*descr. et fig. excl. quae=P. rhodoxanthus* ssp. *europaeus*)
?*Flammula Tammii* Sacc., Syll. **5**:810. 1887.

PLATE I, FIG. 11–12.

Ssp. **foliiporus** Murr. *l.c.*

Pileus when fresh between "maroon" and "claret brown," or between "russet" and "hazel," or "russet," or "ochraceous tawny," or "buckthorn brown," when old (sooner in sunny weather) fading to between "buckthorn brown" and "Isabella color" or to between "Isabella color" and "chamois," non-viscid, subtomentose or tomentose, in many specimens with soft wart-like projections, glabrescent with age, and often becoming rimulose or rimose (mostly concentrically), with the margin forming an obtuse angle (about 90°) in old specimens, convex, soon with flat or even slightly depressed center, margin eventually also flattening, 18–145 mm. broad. — *Hymenophore* "strontian yellow" or between this and "lemon yellow", turning blue in fresh material where wounded, eventually more sordid-brownish, decurrent, lamellae broad (7–14 mm. broad), their edges never forming pores and only the bases (near the line of attachment to the context of the pileus) up to one third of the breadth of the lamellae, rarely higher up, connected by transversely or obtusely forking veins, the sides of the lamellae often transversely veined, the edges entire and somewhat darkening in age; spore print brownish olivaceous, becoming "chipmunk" (M. & P.) in older herbarium preparations. — *Stipe* reddish brown above (colors much like those of the pileus), at least the furfuraceous squamulae or farinaceous pruinosity of the apex, and also the thin ribs continuing the lamellae, besides with a belt of reddish brown below the apex in most specimens, otherwise more olivaceous below, or yellow (concolorous with

the hymenophore) above, the reddish-brown colors eventually gradually disappearing, grayish greenish pallid below from a tomentose-flocculose covering, or, if glabrous, merely pallid there, not viscid, solid, equal or tapering downward, 16–55 x 2–40 mm.; mycelium either yellowish white or rich yellow; veil none. — *Context* yellowish white, pale yellow, or yellow, bluing when quite fresh and young; odor faint as in *Xerocomus subtomentosus*, *X. illudens* etc.; taste mild.

Spores 11–15 x 4.5–5.8 μ, melleous, smooth, oblong-ellipsoid to subfusoid, often the upper half only tapering to the apex; *basidia* 29–42 x 8–14.5 μ, mostly 4-spored, only occasional 3-spored ones mixed in, which measure 31–36 x 7.5–8.5 μ, and very rare 2-spored ones exceptionally found (*e.g.* 43 x 6.5 μ); *cystidia* 51–95 x 7–20 μ, fusoid, more rarely clavate, rarely cylindric, apiculate but obtuse at the tip, hyaline or with a melleous apex, rarely entirely melleous, and very slightly so in most cases, numerous, especially near the edges, the larger ones mostly found near the edges; *trama* consisting of a mediostratum of subparallel-subinterwoven hyphae that are more irregularly interwoven near the base of the lamella, and a lateral stratum of slightly though distinctly divergent (parallel with each other) hyphae which are not or not much more loosely arranged than the hyphae of the mediostratum and consequently also not or not much paler than these; *hyphae* in most carpophores without clamp connections, but occasional carpophores with a few clamped septa are observed.

Chemical reactions: **KOH** on surface of pileus, deep rich blue; on lamellae, brown; on context brownish. — **NH_3** and **NH_4OH** on not yet discolored surface of pileus, quickly bright but intensely pure blue to green-blue, eventually reaching "Hay's brown" as everywhere else in the carpophore. — **Aniline** negative. — **Formol** negative. — **Methylparamidophenol** negative.

Habitat: On the ground in hammocks as well as in open woods, also on trunks of trees (*Sabal*, *Quercus*, *Pinus*) in frondose woods, mostly near *Quercus* spec., and also in coniferous woods, mostly near *Pinus australis*, solitary or gregarious, fruiting from May to November.

Distribution: Florida.

Material studied: **Fla.,** Highlands Co., Highlands Hammock State Park, *R. Singer*, *F 223/I* and *F 223/I a* (FH), *F 632* (FH); Sebring, *R. Singer*, *F 439* (FH); Polk Co., Lake Alfred, *A. S. Rhoads* (*det.* Murrill) (FLAS); Alachua Co., Gainesville, *R. Singer*, *F 2183* (FH); *F 2629* (FH); *W. A. Murrill*, (**authentic**) *F 17990* (FLAS); Sugarfoot Hammock, *E. West*, *L. Arnold*, *W. A. Murrill*, *F 17747* (**type**) (FLAS, FH); *F 17774* (**cotype**) (FLAS); *F 15728* (FLAS); *F 18157* a young stage, **authentic** *F 18157* (FLAS); Magnesia Springs, *E. West*, *L. Arnold*, *W. A. Murrill*, (**authentic**) *F 17991* (FLAS); Columbia Co., High Springs, *W. A. Murrill*, (**authentic**) *F 15599* (FLAS); Dade Co., Brickell's Hammock, Miami, *R. Singer*, *F 940* (FH).

P. rhodoxanthus ssp. *foliiporus* (Murr.) Sing. is found in two forms, one with yellow mycelium, and another one with whitish mycelium. It is pos-

sible that these are hereditary forms which however would be of negligible taxonomic importance unless coupled with some other character. We have not been able, thus far, to ascertain any correlation of this kind.

When reading the diagnosis of *Gomphidius foliiporus* Murr., one may be impressed by the allegedly pallid lamellae and the dark spores. The specimens, however, including the type, do not show any appreciable differences, either macroscopical or microscopical, from the specimens determined by Murrill as *Phylloporus rhodoxanthus*. In fact, the latter as well as *G. foliiporus* are identical. The common *Phylloporus* in and around Gainesville, Fla., always had yellow lamellae when young and fresh, never pallid ones, and the spores were of the ordinary color in the Xerocomoideae in print as well as under the microscope. Fries indicates spores of a different color for his *Agaricus Tammii*, but this should not have influenced the descriptions of *P. rhodoxanthus* because Fries' indication is either an error, or *A. Tammii* is not a *Phylloporus* but rather a *Gymnocybe*.

This does not mean that *G. foliiporus* is a plain synonym of the northern *P. rhodoxanthus*. It is rather a geographic race of the latter. The difference between this and the other races of *P. rhodoxanthus* does not consist in the characters emphasized by Murrill but in the characters opposed to each other in the following key.

KEY TO THE SUBSPECIES OF PHYLLOPORUS RHODOXANTHUS

A. Context changing to blue (green), or "black" by autoxydation when wounded, at least lamellae bluing or "blackening" when quite young and fresh; tropical and subtropical races.

  B. Spores 11–15 x 4.5–5.8 μ; American race. ssp. *foliiporus*

  B. Spores 7.5–11 x (3.5)–4–5 μ; East Indian race. ssp. *bogoriensis*

A. Context unchanging or changing to reddish or brownish red when wounded; lamellae never bluing or blackening even when young and fresh. Temperate races.

  C. Anastomoses of the lamellae constant and broad (high), reaching half the breadth of the lamellae, or more, more rarely less; decurrent ribs at the apex of the stipe forming a proliferation of the lamellae, either absent, or rather indistinct, even if mycelium yellow. ssp. *europaeus*

  C. Anastomoses of the lamellae mostly vein-like, rarely higher and then only toward the margin of the pileus, or near the stipe, and even there not surpassing half the breadth of the lamellae, sometimes entirely lacking; from the point of attachment of each lamella at the stipe, a longitudinal vein or rib runs down the apex of the stipe in all forms with yellow mycelium; American race. ssp. *americanus*

Ssp. **bogoriensis** (Hoehn. *l.c.*) Sing. comb. nov.

The examination of the type material (FH) makes it evident that this species is another race of *P. rhodoxanthus*. Aside from the somewhat problematic difference between bluing and blackening, we find the spores slightly smaller in all three collections from Java than they are in our Florida material; the basidia are about 35 x 10.5 μ, 4-spored; cystidia either hyaline or brownish, cylindric, clavate, or fusoid, with 0.8 μ thick

walls, bluntly rounded at apex, numerous, especially near the edge, 44–105 x 11–20 μ; tramal structure as in ssp. *foliiporus*; no clamps seen.

Assuming as wide a variation of characters as is found in the Florida subspecies, it may be concluded that all three collections of Hoehnel's are the same thing. Even the material marked "Tjibodas" and "Zwergexemplare" is hardly different though it shows some similarities with material collected in Indo-China and China which rather belongs in ssp. *americanus*. Specimens without notes on color changes from the Singapore Botanic Garden were collected by Baker and remained undetermined in Patouillard's Herbarium (FH). I think they belong to ssp. *bogoriensis*.

Ssp. **americanus** Sing., Rev. de Mycol. **3**:171. 1938.

Lloyd has first mentioned the difference in the hymenophore of the American form, the type form of *P. rhodoxanthus*, and the European form. The specimens we have collected in this country and the specimens preserved in the herbaria, as far as they have been found in North America, can be divided in two basic forms, one with whitish mycelium, and wanting ribs on the apex of the stipe, and one, usually larger, with yellow mycelium, and very distinct longitudinal veins or ribs on the apex of the stipe. The form with whitish mycelium has been found in New Brunswick, Canada, and in northern New England, while the form with yellow mycelium is known from southern New England to the Carolinas and perhaps Georgia. The type of *P. rhodoxanthus* ssp. *americanus* Sing. is, of course, the specimen on which Schweinitz based his *Agaricus rhodoxanthus*, and this is obviously the form with yellow mycelium. It so appears that the form with white mycelium does not belong in the same subspecies with the typical ssp. *americanus*. However, more data are needed in order to make sure that this actually is another geographical race, and besides, it will have to be proved that it is not identical with any European form.

The spores are rather variable in both American forms, in the white-mycelioid form varying from 10–11 x 3.3–4 μ in New Hampshire material to 11.5–13.5 x 4–4.8 μ in New Brunswick material; in the yellow-mycelioid form they usually are 10.5–12.5–(14.3) x 4–5.5 μ; basidia 20–30 x 6–8.3 μ, with four 5 μ long sterigmata; cystidia hyaline or in old herbarium specimens with a slight yellowish tinge, cylindric or cylindric-fusoid, also sometimes clavate with 0.5–0.8 μ thick wall, rather numerous to very numerous, 50–111 x 6–19 μ; trama as in the other subspecies; no clamps found.

Material from eastern Asia seems to belong here. The description given by Imai for Hokkaido material fits well. We have also examined Chinese collections with the spores 9.2–15 x 3.7–5.5 μ; basidia 29–32 x 7–9 μ, 4-spored; cystidia hyaline to very pale yellowish with 0.7 μ thick wall, clavate or fusoid, also sometimes cylindric, 40–110 x 7–19 μ; trama as in the other subspecies; clamps none; color of the mycelium yellow; ribs at apex of stipe distinct. Patouillard's type (FH) of his *Paxillus sulcatus* from Indo-China has 11–12.8 x 4.5–5–(6) μ large spores (a few foreign spores from *Boletellus*, probably *B. emodensis*, have fallen onto the hymenophore of the

type specimen); basidia and cystidia as in the yellow-mycelioid form of ssp. *americanus*.

Lebedeva claims that she had *P. rhodoxanthus* from the Far-Eastern Province of the U.S.S.R. Thus this race probably occurs all through Eastern Asia from there through Japan and Eastern China to French-Indo-China.

Ssp. **europaeus** Sing., Rev. de Mycol. **3**:171. 1938.

Good European material from St. Johann in Tyrol, *v. Hoehnel*, 1908 (FH) has recently been consulted by this author and the mycelium has been found to be yellow while the apical ribs were absent or very indistinct; the spores were 11–14 x (3.3)–4.2–5 μ; basidia 35–44 x 8.5 μ, 4-spored; cystidia yellowish-brownish to hyaline, 45–70 x (5.5)–10 μ, fusoid; trama not studied, clamps none.

SPECIES INCOMPLETELY KNOWN

Phylloporus infundibuliformis (Cleland) Sing. comb. nov.

Paxillus infundibuliformis Cleland, Toadst. & Mushr. **1**:175. 1934.

This is evidently a *Phylloporus* but not conspecific with *P. rhodoxanthus*, as far as can be concluded from the description. What is described as *P. paradoxus* by Cleland is a subspecies of *P. rhodoxanthus*, probably an undescribed one, or else ssp. *americanus* or ssp. *bogoriensis*.

SPECIES EXCLUDENDAE

Phylloporus malaccensis Pat. & Baker is *Porphyrellus malaccensis* (Pat. & Bak.) Sing.
Phylloporus intermedius Pat. is *Gyrodon intermedius* (Pat.) Sing.
Phylloporus Rompelii Pat. & Rick.

This species is *Gyrodon Rompelii* (Pat. & Rick) Sing., and perhaps a variety of *G. merulioides* (Schw.) Sing.

Phylloporus lariceti Sing.

This species is here treated as the type of the new genus *Psiloboletinus*.

Phylloporus squarrosoides (Snell & Dick) Sing.

This species may very well be treated as a *Phylloporus*, but in the present arrangement it is transferred to *Xerocomus*.

Xerocomus Quél., Flor. Mycol., p. 417. 1888.

Xerocomopsis Reichert, Palest. Journ. Bot., Reh. Ser., **3**:229. 1940.

Pileus more or less tomentose or subtomentose, frequently with at least fragmentary trichodermium-pallisade; hymenophore not lamellate but occasionally subboletinoid, most frequently with rather wide and angular pores, adnate, often with a decurrent tooth, or arcuate-decurrent, more rarely becoming depressed around the stipe and then usually with the radial walls of the tubes forming a sublamellate ring around the apex of

the stipe, not free, but sometimes separating in age; stipe usually cylindric or subequal and rather thin, more rarely some other shape, and very rarely ventricose-bulbous as in *Boletus*, sometimes with an ocher brown or yellow coarse network at the apex, never finely reticulate as in *Boletus*; veil none; yellow pulverulence none; spores variable in size but constant in shape, *i.e.* always subcylindric to subfusoid, or oblong-ellipsoid to ellipsoid-subclavate, always olivaceous-brown in print (never yellow, ferruginous, pinkish-vinaceous etc.); trama of the hymenophore subbilateral of the *Phylloporus*-type, *i.e.* the lateral stratum scarcely (if at all) lighter colored, and scarcely (if at all) looser than the mediostratum, its hyphae though distinctly diverging in youth, not strongly bent outward, and not distinctly imbedded in a mucilaginous mass, parallel with each other; hyphae without clamp connections; cystidia medium-sized to rather large, not strikingly incrusted or not incrusted at all, not in fascicles; setae none; mycelium white or yellow, not constantly forming mycorrhiza with conifers (except a few species which do not occur in Florida). — The type species is *Xerocomus subtomentosus* (L. *ex* Fr.) Quél.[13]

The genus *Xerocomus* is the one genus among the Boletineae that is most difficult to delimit, and yet it appears to be indispensable from a practical as well as theoretical point of view. It undoubtedly represents itself as a link between *Phylloporus* on one side and *Boletus sensu str.* on the other. As for its limits with *Phylloporus*, I have been tempted to redefine *Phylloporus* by introducing into that genus species with definite pores such as *Xerocomus illudens* and the related species showing the characteristic vivid blue ammonia-reaction on the surface of the pileus known also in *Phylloporus*. In fact these species are so closely related to *Phylloporus* that they almost form a continuous line, and the dividing line between *Phylloporus* and *Xerocomus* could as well have been drawn along chemical as along macro-morphological characters. Unfortunately these convenient and reasonably sharp characters are not entirely parallel, since the blue ammonia-reaction is found on some porous species. I finally chose the macro-morphological criterion for the distinction of the two genera for two practical reasons. First, this character has in its favor tradition as well as the greater convenience of immediate recognition in old, dry, or dried material. Second, a modification of the vivid blue reaction which is found in other species of *Xerocomus* either as a flash of black-blue or a livid-caesious ring around the stained spot, or a violet shade of blue, may cause confusion notwithstanding their obvious difference from the coloration observed in *Phylloporus*. This more conservative solution, leaving *X. illudens* and allied forms

[13] It would mean to reduce *Xerocomus* to the status of a synonym of *Boletus*, if the first species mentioned by Quélet, *Xerocomus impolitus* were to be the type of the genus, as has been proposed by others. This latter proposal, however, was made as a consequence of a misinterpretation of the rules which do not prescribe the choice of the first-described species. *Xerocomus*, as conceived by its author, is the group centering around *X. subtomentosus*, and therefore this author in 1936 proposed this latter species as lecto-type.

in *Xerocomus*, has also the advantage of keeping within a single genus such species as *X. illudens*, *X. spadiceus sensu* Quél. = *X. coniferarum* and *X. subtomentosus* which were in the past even considered to be varieties of one and the same species. I may add, however, that there is not enough evidence to prove that *X. illudens* and *X. coniferarum* actually are more closely related to the rest of the *Xerocomi* than with *Phylloporus*.

On the other extreme of the genus *Xerocomus* are forms which apparently gradually approach the genus *Boletus sensu str.* In these, the pores are somewhat smaller than in the others, and the structure of the lateral stratum of the hymenophoral trama becomes more truly bilateral (*Boletus*-type). In fact, even macroscopically, no sharp line between these two genera can be drawn. If, however, the exact structure of the trama and the affinities of every single intermediate species are checked and weighed, a line between these genera will result that is somewhat hard to define but evidently leaves related forms together and makes both genera as natural as possible.

Two important papers on the anatomy of the hymenophoral trama in the boletes have appeared recently. The first authors to mention the difference between what we call the *Phylloporus*-type and the *Boletus*-type, were Lohwag and Peringer (Ann. Mycol. **35:**295–338. 1937). Their results were checked by this author on the limited amount of material in 1938 and found to be correct. I may add that in my key to the genera of the Agaricales (Schweizer. Zeitschr. Pilzk. **17:**7. 1939) I have for the first time used the two types of bilaterality for taxonomic purposes. In a later paper, Elrod and Blanchard (Mycologia **31:**704. 1939) also published on the structure of the trama of the Boletaceae but did not arrive at the same results as their predecessors. In fact, they concluded that though there was plenty of difference in different species, this difference did not coincide with any classification based on other characters and can therefore not be used for taxonomic purposes. I have regretted that these authors did not publish precisely what structure they found in what species and at what stage. If they had, it would probably become more apparent that the differences they found cannot, in many cases, be used for taxonomic purposes because they do not exist between species but between stages. I have now checked on young and good material of most of the specimens available for this purpose (see descriptions and notes on extralimital material), and rechecked on my own findings in long and tedious investigations. If care is taken to use for these investigations nothing but comparatively recent collections and carpophores just beginning to sporulate, it will be found that there is a bilateral trama in all Boletaceae with a single modification, that is the existence of the *Phylloporus*- and *Boletus*-type of bilaterality. As soon as the tubes begin to elongate, the divergence of the hyphae of the lateral stratum diminishes slowly until it finally reaches zero *i.e.* the hyphae show a generally axillar direction, parallel with each other and with the mediostratum. On the other hand, there is no bolete among the scores of specimens I have sectioned that does not show distinctly (though to a different

degree) divergent hyphae in the lateral stratum at a certain age. Even the difference between the *Phylloporus*- and *Boletus*-type is rather a quantitative than a qualitative one. It is only natural that, under these circumstances, intermediate structures occasionally may be observed. An example is section *Pseudoboleti* with thus far one species, *X. badius*. Since the disposal of the species with intermediate structure has been taken care of in an arbitrary way, with the idea of keeping related forms together, the keys to the species of *Boletus* (now in preparation) take into account both species here considered as belonging to *Xerocomus*, and species considered as *Boletus* (*sensu str.*).

KEY TO THE SECTIONS

A. Spores short (Q=2, or less), *or* reaction of the surface of the pileus with ammonia an intense, vivid pure blue or green-blue (about "porcelain blue" or "dusky green blue"), not blackish blue, nor violet, livid, or caesious. Sect. 1. *Pseudophyllopori*

A. Spores elongate *and* reaction with ammonia not as described above.

B. Pileus not or scarcely viscid in wet weather; species growing entirely as saprophytes, or with northern forest trees, or parasitic on fungi.

C. Not parasitic on fungi; spore production of the hymenophore abundant; context potentially bluing, or at least fresh tubes sometimes bluing. Sect. 2. *Subtomentosi*

C. Parasitic on fungi (Sclerodermatineae); spore production not as active as in other boletes; context not or scarcely bluing, not even in the tubes. Sect. 3. *Parasitici*

B. Pileus distinctly viscid in wet weather; either forming mycorrhiza with northern conifers exclusively, or connected with southern hardwoods, sometimes in open places.

D. Carpophores small; spores smaller than 10 μ; context and pores unchanging; species never connected with conifer mycorrhiza. Sect. 4. *Brasilienses*

D. Carpophores medium to rather large with medium (longer than 10 μ) to rather large spores; context bluing; northern species, always connected with conifer mycorrhiza. Sect. 5. *Pseudoboleti*

Sect. **Pseudophyllopori** Sing. sect. nov.

Sporis breviusculis (quotiente e longitudine et latitudine vix superante 2) aut reactione NH_3 et NH_4OH in superficie pilei provocata intense azurea vel viridulo-azurea.

Characters of the section: Pileus not viscid; surface of pileus in the species studied turning immediately to an intense, vivid pure blue or green-blue (about "porcelain blue" or "dusky green blue"), at least when young and fresh, neither water-soaked nor too dry; pores wide; spores either short (Q=2, or less), or of normal elongated shape; context bluing or not bluing; habitat on the ground or on wood in frondose and coniferous woods, hammocks, and in gardens near trees, never parasitic on fungi.[14] — The type species is *X. illudens* (Peck) Sing. (*Boletus illudens* Peck).

[14] It is not known whether these species form mycorrhiza. If they do, they evidently prefer frondose trees, especially oaks, hornbeam, and perhaps sweet gum and others. However, one species grows with conifers (*X. coniferarum*).

KEY TO THE SPECIES

A. Spores with Q averaging around 2 or somewhat smaller.
  B. Pores large, subboletinoid, angular; spores 9–12 x 4.5–6 μ. *X. squarrosoides*
  B. Pores medium-sized, circular to oblong; spores 7.7–8.5 x 5 μ. *X. Housei*

A. Spores with Q decidedly above 2.
  C. Stipe without a network in all specimens of a given group, *i.e.* constantly smooth; spores 4–5 μ broad or broader; growing with oaks (in Florida).
    D. Base of stipe distinctly bright yellow; mycelium yellow; carpophores small and thin. 12. *X. hypoxanthus*
    D. Base of stipe not distinctly yellow; mycelium yellowish white to white; carpophore large and thick (in Florida).
      E. Floridan species; carpophores large, thick, growing in scrub and in low oak woods; hymenophore a rich yellow 13. *X. pseudoboletinus*
      E. African species; carpophores rather small and rather thin, growing at the base of termite nests; hymenophore pinkish cinnamon. *X. Linderi*
  C. Stipe with a network, at least at the apex in most specimens of a group (sometimes the network is incomplete, and replaced by a coarse brown punctation on yellowish ground, but the majority of carpophores shows them connected enough to form a well-distinguishable network); spores either about 4–5 μ broad, or narrower.
    F. Pileus usually tapering down into the thin, frequently curved stipe, and thus the hymenophore distinctly arcuate-decurrent; tubes very gradually transient into the coarse network (ridges or punctation) of the stipe; mycelium white or yellowish white; spores 4–5 μ broad; habitat around trunks in dense hammocks, more rarely farther away from the trunks on humus. 14. *X. hemixanthus*
    F. Pileus not shaped as described above, and consequently the hymenophore either flatly adnate (though sometimes plainly decurrent on one side because of irregularity of growth), and only slightly decurrent with a tooth, the walls proliferating into the network of the apex of the stipe but not very gradually so; mycelium yellowish white or yellow; spores 3.5–4.2 μ broad in eastern species, often broader in others; growing in small groups not arranged around the trunks of trees, usually in rather open stands of northern woods, or in partly cultivated hammock land, in gardens etc.
      G. In beech woods (*Fagus*) and in coniferous woods, in Europe, perhaps in North America; spores (3.5)–4–5–(6) μ broad, most frequent sizes 11.5–13 x 4.8 μ; mycelium yellow and then carpophores large and the stipe not tapering downwards, *or* mycelium white and then carpophores medium-sized to rather small with the apex of the stipe deeply reticulate.
        H. Stipe brown, very strongly reticulated, pallid near the base, equal or tapering downward; carpophores medium-sized, or perhaps rather small; in beech woods (according to Rostkovius). *X. lanatus*
        H. Stipe yellow with more or less deeply decurrent brown network; the base and the mycelium yellow, stipe subequal or tapering upward; large plant in coniferous woods. *X. coniferarum*

G. In mixed oak woods and on lawns and in gardens under frondose trees other than beech, mostly oak in the eastern part of North America; spores 3.5–4.5 μ broad, most frequently 10–11.7 x 3.5–4.1 μ; mycelium yellow and then carpophores medium-sized and the stipe distinctly tapering downward in most cases, *or* mycelium white or yellowish white, and then carpophores large with the stipe yellow and brown-reticulate. 15. *X. illudens*

I. Mycelium white to yellowish white; carpophores large (pileus 63–123 mm. broad; stipe 40–60 x 25–35 mm.); the brown network of the stipe usually reaching deep toward the base. Northern plant. ssp. *typicus*

I. Mycelium yellow; medium-sized carpophores (pileus 43–87 mm. broad; stipe 35–70 x 8–18 mm.); the brown network of the stipe usually confined to the upper portion of the stipe. Known only from Florida. ssp. *xanthomycelinus*

12. **Xerocomus hypoxanthus** Sing. spec. nov.

Pileo dilute brunneolo, ochraceo-brunneo-punctatulo (velutino-punctatulo vel fibrilloso-granulosulo) vel tomentoso, sicco, convexo, 26–66 mm. lato, ammonici ope vivide azureo; tubulis flavis, deinde subolivaceis, saepe tactu subvirescentibus, adnatis vel subdepressis; sporis 11–14 x 4.2–5.2 μ, brunneo-olivascentibus in cumulo recente; stipite flavo, deorsum pallido vel pallide flavo, sed brunneolo-granuloso-subsquamuloso, squamulis minutis subsparsis obtecto, aequali, mycelio flavo, 30–50 x 4–10 mm.; carne alba vel albida, flavidula vel flava, laesa subtiliter caerulescente in pileo, inodora, miti. Habitatio: In dumetis subtropicis ("low hammock") et silvis arenosis ("scrub") prope quercus et arbores alias frondosas aestate in Florida Americae Borealis.

Pileus pale brownish but appearing much more vivid brown because of a dense fibrillose-granular velvet or a tomentum that is "mahogany red," "Brussels brown," "russet," "Mars brown," or "ochraceous tawny," and by side view (seen at an acute angle) usually rather "buckthorn brown," non-viscid, only subviscid when wetted thoroughly, not reddening in cracks, 26–28 mm. broad but occasionally reaching 66 mm. in diameter. — *Hymenophore* "strontian yellow" with a tinge of "oil yellow" or "pyrite yellow," adnate-subdecurrent or planely adnate, or slightly depressed around the stipe, or lamellately stretched near the stipe, and finally separating from it, pores concolorous and greening on pressure or unchanging, wide; spore print not obtained in thick enough layer but of about the same color as in the following species. — *Stipe* pallid to pale yellow or pale tawny and mostly more vivid yellow at the apex ("light cadmium" to "lemon chrome"), and usually likewise yellow at the very base where the finely fibrillose bright yellow mycelium is attached, the yellow of the surface of the middle portion usually obscured by the "Argus brown" granular punctation or furfuraceous pustulation which becomes denser downwards but is usually sparse and the particles minute farther above, though occasionally it forms an annular belt of denser granulae (not a veil), non-viscid, solid, thin, subequal or equal, 20–32 x 2–4.5 mm. but sometimes reaching 50 x 10 mm. — *Context* white or with a very faint yellowish tinge in the pileus, reaching "Martius yellow" to "strontian yellow," pallid to light yellow in the stipe

but often lemon yellow in the apex of the stipe and often marbled, the context of the pileus never becoming reddish in wounds or cracks, unchanging when bruised, or sometimes slightly bluing; taste mild; odor none or very slight, like that of *Boletus edulis*; taste mild.

Spores (8.2)–11–14 x 4.2–5.2 μ, smooth, melleous, fusoid with suprahilar depression; *basidia* 26–41.5 x 8.5–11 μ, most frequently 26–36 x 9.5–10 μ, 4-spored, very rarely some few basidia 2-spored; *pseudoparaphyses* clavate with subcapitate apex, or basidiomorphous, *e.g.* 33 x (5)–8–11.5 μ, not always present; *cystidia* 34–70 x 6.8–12.2 μ, fusoid with the thickest portion in the middle or in the upper third, with the apex obtuse and often ampullaceous protracted, hyaline, rather numerous; *trama* of the tube-walls of the same general type as in *X. illudens*; all *hyphae* without clamp connections.

Chemical reactions: **KOH** on pileus, dark and intense blue, in older and drier material "amber brown" to "Argus brown"; on the tubes, light brown to brown; on the squamulae of the stipe, deeper brown but ground color unchanged. — **NH_4OH** on the surface of the pileus, deep and rich blue to green-blue when young and fresh, slightly bluish to negative when old or dry; on context, blue to bluish when fresh.

Habitat: On trunks of palmetto between old petioles, on very decayed frondose wood, on the base of frondose trees, or on humus and débris in low and mesophytic hammocks, and on dry sand in scrub areas, from July to September.

Distribution: From Georgia (and perhaps Virginia) south to Florida (except in the tropical part of the state).

Material studied: **Fla.** Highlands Co., Highlands Hammock State Park, *R. Singer, F 626* (**type,** FH); *F 37* (**co-type,** FH); *F 357* (**co-type,** FH); *F 579/I* (**co-type,** a large form of the scrub, FH); Alachua Co., Sugarfoot Hammock, *R. Singer, F 2473 b* (FH); *F 2590/I* (FH). — **Ga.** Tallulah Falls, *A. B. Seymour* (FH).

The combination of characters in this usually small bolete is constant in all collections, and it does not seem to have been described before.

13. **Xerocomus pseudoboletinus** (Murr.) Sing. comb. nov.

Ceriomyces pseudoboletinus Murr., Lloydia **7**:324. 1944.

Pileus "mahogany brown," "Verona brown," "russet," later "sayal brown," "Mikado brown," "ochraceous tawny," or with some "Sanford's brown," or (because of the unequal development or partial lack of the cuticle) as pale as "honey yellow" in the center and "chamois" to "cream buff" on the margin, occasionally with some "pinkish buff" to "pinkish cinnamon" mixed in, sometimes more "cameo brown" at places, tomentose to subvelutinous, more tomentose toward the margin, partially and unequally glabrescent and often areolate-squamose, the squamulae appressed, becoming more distinctly rimulose when old, the yellow of the flesh showing through the crevasses or squamulae, dry, rugulose to smooth, margin incurved and slightly projecting when young, the projecting portion pallid

underneath, pulvinate, then convex with an occasional depression in the center, 40–170 mm. broad. — *Hymenophore* "lemon chrome" or between "lemon chrome" and "lemon yellow," or "sulphine yellow," becoming "sulphine yellow" or "lemon yellow" when older, then "citrine" with more "lemon yellow" pores, adnate or shallowly depressed; tubes 10–17 mm. long, the radial walls of the tubes often short-decurrent (1–6 mm.) and occasionally with anastomosing lines; pores on unequal level, radially elongate, at least near the stipe, 0.5–2.5 mm. wide, 3–5 pores to 5 mm. radially, and 5–6 pores to 5 mm. transversely; spore print brownish olive. — *Stipe* "naphthalene yellow," "primulin yellow," "strontian yellow," or "ivory yellow" with "colonial buff" punctations, often at places almost white, often concolorous with the pileus near the base, or near the base or in the middle "onion skin pink," "pecan brown," or "walnut brown," dry, not reticulate, without furfuraceous or reticulate brown ornamentations, even at the apex, but with occasional short longitudinal coarse ribs which are subconcolorous with the pileus and rarely show a slight anastomosis, otherwise quite smooth, but never really glabrous because of a minute, mostly yellowish or pale tan punctation all over its surface, though often seemingly subglabrous because the punctation does not show except when observed with a lens, subequal or tapering downward and frequently with a strongly enlarged apex, solid, 35–50 x 8–18 mm., the apex sometimes up to 40 mm. wide. — *Context* "pale lemon yellow," "lemon yellow," or "barium yellow" near the tubes and yellowish white to "naphthalene yellow" or almost white with yellow stripes in the stipe, otherwise yellowish white to nearly white, often somewhat pinkish under the surface, either entirely unchanging in any part, or more rarely slowly and weakly greening in the deeper yellow portions of the context; odor of soap, or none; taste mild, submild, or scarcely bitterish.

Spores 10.2–13.7 x 4–5.5 μ, subfusoid or ellipsoid-oblong with suprahilar depression, more rarely without it, smooth, melleous; *basidia* 22.5–43 x 8.8–11.7 μ (larger in the dry scrub areas than in moist hammocks), hyaline to pale melleous, 4-spored; *cystidia* on pores and inside the tubes narrowly fusoid or broadly fusoid with long cylindric neck which rarely is subacute, and usually obtuse, hyaline to more rarely pale melleous, 37–56 x 4.5–8 μ; *cheilocystidia* sometimes differentiated, versiform; *trama* of the hymenophore decidedly of the *Phylloporus*-type; *hyphae* without clamp connections, hyaline.

Chemical reactions: **KOH** on surface of pileus, "amber brown," then "Argus brown" or still deeper brown, later becoming paler; on context of pileus, brownish; on context of stipe, negative or almost so; on tubes, brownish; on surface of stipe, negative. — **NH_4OH** (and also NH_3 vapors) on surface of pileus (if fresh enough), becoming "porcelain blue" to "dusky green-blue," less vivid on older caps, or in the old ones becoming "dull Indian purple" or duller, or deep brown on old, dry pilei, then becoming paler, the vapors usually reacting similarly[15]; the portions treated with

[15] In strongly cracked or squamose pilei, the reaction is likely to be indistinct.

$FeSO_4$ previously, and subsequently exposed to the action of ammonia show the same blue reaction as fresh young material, even if the material be rather old and dry (catalysis?); on context of stipe, negative except in some cases where the deep yellow portions of the flesh change to bluish green with ammonia. — **$FeSO_4$** on surface of pileus, see under NH_4OH; on context of pileus, slowly dirty greenish. — **H_2SO_4** on surface of pileus, reddish fulvous; on tubes, rusty-ochraceous; on context of pileus, negative then sometimes blue. — **HNO_3** on surface of pileus, reddish fulvous; on the entire context, slightly reddish brown, generally causing a richer and brighter color. — **Formol** on context of pileus, negative and later somewhat blue.

Habitat: Under scrub oaks (*Quercus Chapmanii* and other species) turkey oak (*Q. laevis*), water oak (*Q. nigra*), laurel oak (*Q. laurifolia*), live oak (*Q. virginiana*), with *Q. minima*, in the scrub, low open places, on lawns, and even in flatwoods, on dry sandy as well as on wet acid soil. Fruiting from July to October.

Distribution: Florida (excepting the tropical part).

Material studied: **Fla.** Highlands Co., Highlands Hammock State Park, in the scrub areas, *R. Singer, F 579* (FH); Alachua Co., near Dayville, southwest of Gainesville, near the pond, *R. Singer, F 2540,* (FH); *F 3029* (FH); between Gainesville and Newnan's Lake in flatwoods, *R. Singer, F 2841* (FH); *W. A. Murrill, F 19589,* **co-type,** (FLAS, FH); Gainesville, *R. Singer, F 2764* (FH); also less well-preserved material without notes, determined as *B. illudens* by W. A. Murrill (FLAS).

This species has obviously been considered as *B. illudens* by Murrill and later has been described as a new species by him. It was already given as a new species in this manuscript when a sample of *C. pseudoboletinus* reached me.

14. **Xerocomus hemixanthus** Sing. spec. nov.

Pileo brunneo vel brunneo-umbrino, castaneo vel ferrugineo in junioribus, fulvo-rubido vel ferruginascente in vetustis, tomentoso, pulvinato, dein applanato, 27–75 mm. lato; ammoniaci ope caerulescente; tubulis flavis vel flavo-melleis, in vetustus discoloratis, obtuse adnatis vel decurrentibus, plus minusve arcuatis, 5–11 mm. longis, poris concoloribus, amplis at moderate tantum radialiter elongatis, 1.5–2 mm. in diametro in maturis; sporis 10.3–15.3 x 4–5 μ; tramate typi *Phyllopororum*; stipite cremeo, ad apicem vel omnino castaneo-reticulato, aequali vel subaequali, saepe curvato, 30–60 x 5–12 mm.; mycelio albo vel lutescente-albido; carne aequaliter flava vel pallide flava, fracta frequenter caerulescente. Habitatio: In silvis densis frondosis (hammocks) circa et ad bases truncorum arborum, praecipue *Ostryae* aut rarius ad humum, Julio mense in Florida Septentrionali Americae Borealis.

Pileus between "snuff brown" and "Saccardo's umber," or "Dresden brown" when young, between "russet" and "auburn" when old, or similar in color through all stages and then between "chestnut" and "auburn," tomentose, becoming faintly granulose or rimulose-tessellate, non-viscid, pulvinate, then flat, 27–75 mm. broad. — *Hymenophore* "amber yellow," "honey yellow," "Isabella color," sometimes becoming as deeply colored as "Saccardo's umber," at last discolored golden brownish with age, broadly

adnate (with or without a decurrent tooth) or decurrent, more or less arcuate, tubes 5–11 mm. long, pores 1.5–2 mm. wide when mature, *i.e.* wide but only moderately radially elongate. — *Stipe* "cartridge buff" to "cream buff," apex or entire surface adorned with anastomosing ribs or a perfect network, the ribs coarse and "chestnut brown," rarely broken up into minute squamulae of the same color, solid, terete or compressed, equal or subequal, straight or more often curved, 30–60 x 5–12 mm.; mycelium white or yellowish white. — *Context* yellow or pale yellow in both pileus and stipe, occasionally slightly bluing, yellow in dried specimens; taste slightly acidulous or mild; odor none, in old specimens often recalling Roquefort cheese.

Spores 10.3–15.3 x 4–5 μ, fusoid, melleous, smooth; *basidia* 25–31 x 7.5–11 μ, 4-spored; *cystidia* 27–38 x 6–17 μ, rarely longer, always hyaline in well-preserved material, versiform, on pores fasciculate; hymenophoral *trama* of the *Phylloporus*-type; the lateral stratum little though undoubtedly divergent and no differentiation in color or density between it and the mediostratum visible; *terminal members of the cuticular hyphae* upright and often rather short to even subglobose (13–34 μ in diameter), broadly rounded above, not forming an actual epithelium, the rich ferruginous-chestnut-brown pigment squeezed out and dissolved in ammoniacal preparations; *hyphae* without clamp connections.

Chemical reactions: **KOH** on surface of pileus, deep castaneous; on tubes, brown; on context, ochraceous tan. — **NH_3** on surface of pileus and hymenophore, blue. — **NH_4OH** on surface of pileus, tan; on tubes, blue; on context, bluish. — **HNO_3** on surface of pileus, orange then reddish. — **H_2SO_4** on surface of pileus, orange then cinnamon; on tubes, orange-ferruginous.

Habitat: On the bases of the trunks of *Ostrya*, more rarely of *Liquidambar*, *Acer*, or *Carpinus*, usually on the trunks of living trees, rarely on dead trunks, sometimes on humous ground of mesophytic hammocks near *Ostrya* or *Liquidambar*; fruiting in July, gregarious.

Distribution: North Florida.

Material studied: **Fla.** Alachua Co., in and around Gainesville in mesophytic hammocks, *R. Singer, F 2473, F 2473 a, F 2473 b*, etc. (FH).

This species is unmistakable when found typically developed. In its external appearance, it is much like *X. hypoxanthus* but differs in the color of the mycelium and the chestnut brown raised lines on the apex of the stipe; the spores are slightly narrower on an average but there are collections where the spores are equally broad in both species. In *X. squarrosoides* which, at times, is also similar in stature, the spores are distinctly broader.

15. **Xerocomus illudens** (Peck) Sing. comb. nov.

Boletus illudens Peck, Ann. Rep. N.Y. State Mus. **50**:108. 1897.
Ceriomyces illudens Murr., N. Am. Fl. **9**:145. 1910.
Ceriomyces alabamensis Murr., N. Am. Fl. **9**:146. 1910 (a subspecies ?).
Boletus alabamensis Sacc. & Trott., Syll. **21**:242. 1912.
Ceriomyces flavimarginatus Murr., Mycologia **31**:110. 1939. (a subspecies), *p.p.*

Ssp. **typicus.**

Pileus "tawny" to "cinnamon rufous" when fresh, middle portion with "ochraceous tawny" and "cinnamon rufous" or "russet" stains on generally "buckthorn brown" ground, margin becoming slightly more grayish fuscous than "ecru-olive," center subtomentose, margin tomentose, non-viscid, convex, center sometimes depressed, margin thick and fleshy, 63–123 mm. broad. — *Hymenophore* mixed "strontian yellow" and "citron yellow," becoming "pyrite yellow" at last, adnate-subdecurrent, tubes 9–15 mm. long; pores concolorous, sometimes slightly bluing on pressure, 0.8–3.0 mm. wide. — *Stipe* between "primrose yellow" and "marguerite yellow," or between "ivory yellow" and "colonial buff," with either concolorous or tawny brown (color of the pileus) very coarse, wide network of strongly raised, strongly anastomosing lines, most distinct at the apex but reaching down to the very base, with a concolorous or "light pinkish cinnamon" faint fibrillosity at places, or almost all over its surface, solid, decidedly tapering downward, 40–60 x 25–35 mm. at apex; mycelium yellowish white. — *Context* yellowish white with pale brownish pink portions to nearly "massicot yellow," somewhat brownish inside the stipe; odor none, or slightly like *Boletus edulis* but weaker and less aromatic; taste mild.

Spores (8.2)–9.5–12.7–(13.6) x 3.5–4.5 μ, most frequently 10–11.7 x about 4.0 μ, melleous, smooth, ellipsoid-subfusoid to strongly fusoid; *basidia* 28–35 x 7.5–9.2 μ, (2)–4-spored; *cystidia* 42–56 x 6–11 μ, hyaline, non-incrusted, distinctly fusoid, thin- to moderately thick-walled; *trama* of the hymenophore not observed in proper condition, but of the general structure of the related forms; *hyphae* without clamp-connections.

Chemical reactions: **KOH** on surface of pileus, deep chestnut becoming "ochraceous orange" (but reaction weak and slow). — **NH_3** on surface of pileus, deep green-blue. — **$FeSO_4$** on tubes, more greenish and more gray; on context, almost negative.

Habitat: In mixed woods on the ground, from August to September.

Distribution: From New England and upper New York State south to the Carolinas and probably Alabama.

The above description is the result of the study of several good fresh specimens from Massachusetts, dried material from North Carolina (*Alma Holland Beers 12523*) and the type collection at Albany (NYS). Compare also Coker and Beers' description (*l.c.* p. 55). We included this description in order to make the comparison with the Florida subspecies possible.

Ssp. **xanthomycelinus** Sing. ssp. nov.

A subspecie typica mycelio luteo nec non statura paulum minore differt. Sub Quercubus in Florida Americae Borealis.

Pileus reddish brown to fulvous castaneous ("Mikado brown," "auburn," "chestnut"), tomentose, or subrimulose-tomentose when mature, non-viscid, pulvinate to nearly applanate, 43–87 mm. broad. — *Hymenophore* about "strontian yellow" or somewhat paler, becoming more olive yellow with age, adnate or adnate-subdecurrent and continued in the reticulation of the

apex of the stipe; tubes medium long; pores concolorous, unchanging, wide to very wide. — *Stipe* varying from pallid to yellow but if pallid it is covered with numerous dense minute flocculae which make the whole surface appear yellow except for the brownish (testaceous-cinnamon to reddish brown) ridges or ribs that form, on the upper third or two thirds of the stipe, a coarse network from which longitudinal lines frequently run downwards for some distance, solid, tapering downward from the very apex or from about the middle of the stipe, or only with a tapering base and otherwise subequal, 35–70 x 8–12–(18) mm.; mycelium light yellow to rich yellow. — *Context* white with yellow portions above the tubes, or light yellow throughout the pileus, white or sordid pale yellow in the stipe, not changing anywhere, slightly paler than the surface immediately under the cuticle of the pileus; taste mild; odor almost none.

Spores 9.5–14.2 x 3.5–4.5 μ, most frequently 10–11.5 x 3.5–4 μ, melleous, subfusoid-subellipsoid, smooth; *basidia* 24–30 x 7–9 μ, 4-spored, in few carpophores some 2-spored ones intermixed; *cystidia* 28–63 x 5.5–11.5 μ, fusoid or subfusoid, larger and more scattered in the tubes, smaller and more numerous on the pores, with rounded apex, hyaline, occasionally with long slender ampullaceous neck; *trama* of the hymenophore of the *Phylloporus*-type; *hyphae* without clamp-connections.

Chemical reactions: **KOH** on surface of pileus showing a nearly black ring around the stain. — **NH_3** and **NH_4OH** on surface of pileus, strongly and intensely greenish blue or blue, then fading to deep chocolate.

Habitat: On lawns near oaks (*Quercus virginiana* and *Q. laurifolia*) and shrubs in small groups, successively but not abundantly fruiting during the summer (from May to July and probably longer).

Distribution: Northern Florida.

Material studied: **Fla.** Alachua Co., Gainesville, May 1943, *R. Singer, F 2167* (**type,** FH); July 1943, *R. Singer, F 2530, F 2612, F 2620* (**cotypes,** FH).

This subspecies replaced the type form entirely in Gainesville while I was collecting there. However, Murrill has determined a more yellowish specimen with thicker stipe from Alachua County as *B. illudens* (FLAS), and it would not be surprising if this species were neither the type nor the ssp. *xanthomycelinus*. Murrill's *Ceriomyces alabamensis* belongs most probably to one of the subspecies of *X. illudens* but I was unable to find out to which. The spores are not as small as indicated by Murrill but rather 9.5–11.5 x 3.7–4.2 μ in the type specimens.

EXTRALIMITAL SPECIES

Xerocomus squarrosoides (Snell & Dick) Sing. comb. nov.

Boletinus squarrosoides Snell & Dick, Mycologia **28:**468. 1936.
Phylloporus squarrosoides Sing., Rev. de Mycol. **3:**170. 1938.

The excellent description of this species given by its author makes it possible to dispose of this species taxonomically without knowing the

ammonia reaction. There is abundant material at the Farlow Herbarium, authentic material as well as Farlow's material from Providence, R. I. (*Boletinus decipiens*) and Stow, Mass. (*Boletinus castanellus*), and D. H. Linder's collection (*B. subtomentosus*) from Canton, Mass., and besides a fine unpublished color plate (*Br. 312*). It usually has more boletinoid hymenophore than other species of this genus and its color is less yellow or less uniformly yellow than in the others except *X. Linderi.* The spores are melleous-brownish, smooth, asymmetric, ovoid with tapering apex or oblong-ellipsoid, without a distinct suprahilar depression, 9–12 x 4.5–6 μ, mostly about 9.8–10 x 4.8–5 μ; basidia 28–37 x (5.5)–7.7–9 μ, 4-spored; cystidia closely resembling the cystidia of *Phylloporus rhodoxanthus*, either hyaline or melleous, fusoid with mostly broadly rounded tip, more rarely ampullaceous or clavate, 40–73 x 7.5–12.2 μ; trama of the *Phylloporus*-type; hyphae without clamp connections. In 1938, the author placed this species in *Phylloporus*. In the present arrangement we take it with all other porous forms to *Xerocomus*.

Xerocomus Housei (Murr.) Sing. comb. nov.

Ceriomyces Housei Murr., N. Am. Fl. **9**:145. 1910.

The type (NY, NYS) has the spores still shorter than *X. squarrosoides*, ellipsoid-ovoid, smooth, melleous, 7.7–8.5 x 5 μ; basidia 28 x 9.7 μ, 4-spored; cystidia fusoid, narrowly clavate, or fusoid-ampullaceous, rather numerous 35–40 x (5)–9–9.5 μ; cuticle with an interrupted trichodermium-palisade, the terminal hyphae fusoid or subulate, or capitate, 17–42 x 7–22 μ; hyphae clamp-less. It seems that this North Carolina bolete, rarely collected and chemically not studied, belongs in section *Pseudophyllopori.*

Xerocomus Linderi Sing. spec. nov.

Pileo areolato, areolis fulvidis ("tawny 14"), subapplanato, 40 mm. lato, cuticula e trichodermio palisadiformi brevi-hyphoso nec non e catenulis suberectis sphaerocystarum consistente; tubulis carneo-cinnamomeis ("pinkish-cinnamon" R. in vivis), fractis caerulescentibus, amplissimis, angulatis; sporis subfusoideo-ellipsoideis, brunneolo-melleis, levibus, tenui-tunicatis, depressione supra-hilari praeditis, 11–12 x 4.7–5.2 μ; basidiis 30–38 x 9–11 μ, tetrasporis; cystidiis versiformibus, saepius clavatis; stipite argillaceo-cinnamomeo ("clay color") subtus, at ad apicem flocculis fuscidulis ("snuff brown") furfuraceis obsito, solido, aequali, 45 x 5 mm.; mycelio albo, ex hyphis 2.8–3.5 μ crassis cylindraceis consistente; carne sordide ochracea in siccis, tenuiore, odore saporeque haud notatis. Habitatio: Ad basin nidi termitum prope Banga, Liberia Africae, Octobri mense *D. H. Linder, 1211* (**type,** FH).

This is apparently a *Xerocomus* but the section is somewhat difficult to determine. It is in so many ways similar to *X. hemixanthus* and *X. squarrosoides* that we consider it as belonging in section *Pseudophyllopori.*

Xerocomus lanatus (Rostkov.) Sing. comb. nov.

Boletus lanatus Rostkov. in Sturm, Deutschl. Fl., Pilze **3**:77. 1844.
Boletus hieroglyphicus Rostkov. *l.c.* **3**:93. 1844.
Boletus Leguei Boud., Bull. Soc. Mycol. Fr. **10**:62. 1894.
Suillus lanatus Kuntze, Rev. Gen. Plant. $\mathbf{3}^2$:535. 1898.
Boletus subtomentosus var. *Leguei* Bat., Bolets, p. 19. 1908.

Xerocomus subtomentosus var. *Leguei* R. Maire, Publ. Inst. Botàn. Barcelona, **3**(4):43. 1935.
Boletus subtomentosus ssp. *spadiceus* var. *lanatus* Konr. & Maubl. Icon. Sel. Fung. **6**:463. 1938.

The author has seen material in Boudier's herbarium at Paris. According to Rostkovius it is found in beech woods, and according to Boudier, the spores are very broad, much broader than in *X. illudens*.

Xerocomus coniferarum Sing. nom. nov.

Boletus ferrugineus Bres., Iconogr. **19**, *pl. 915*. 1931, *non* Schaeff. *nec* Frost.

This is also the *B. spadiceus* "Fr." *sensu* Quél., Champ. Jura, p. 262. 1872, *X. spadiceus* (Fr. *sensu* Quél.) Quél., *B. subtomentosus* ssp. *spadiceus* (Fr. *sensu* Quél.) Konr. & Maubl. It occurs under fir in the Vosges Mts. in France, also in the Trentino, and the Caucasus.

Sect. **Subtomentosi** Fr., Epicrisis, p. 412. 1838 (sect. gen. *Boleti*).

Characters of the section: see key p. 287. Type species: *X. subtomentosus* (L. *ex* Fr.) Quél. Other species: *X. chrysenteron* (Bull. *ex* Fr.) Quél., *X. Zelleri* (Murr.) Snell *apud* Slipp & Snell. It is possible that some tropical species belong in this section. One of the species which the author tentatively places here, is:

Xerocomus Junghuhnii (Hoehn.) Sing. comb. nov.

Boletus Junghuhnii Hoehn., Sitz.-ber. k. Akad. Wiss. Wien, Math. Nat. Kl. **123** (I):87. 1914.

The type (FH) from Java which we have examined in order to be able to compare it with *X. brasiliensis*, shows very large pores in a very small carpophore. Hoehnel states that the pileus is dry. In one of the transparent bags containing type material, specimens of another species (a minute *Boletus*) are intermixed, but the descriptive notes seem to entirely correspond to the species which we take for the real *X. Junghuhnii*. Even there, we find the spores very variable in size but not so much in shape. They are pale melleous ("pale yellowish in masses" says Hoehnel but he had no good spore print) under the microscope, smooth, and varying between 9–10 x 3.8–4.2 μ in one mature specimen to (9.2)–10.2–13.3 x (3.8)–4.2–5.3 μ in another; basidia 23.8–25.3 x 6.8–8.8 μ; cystidia versiform, not always conspicuous, about 35–42 x 8.5–12.5 μ; hyphae of cuticle with yellow cell sap; clamps none; structure of the trama not with certainty decipherable.

Sect. **Parasitici** Sing., Ann. Mycol. **40**:43. 1942.

Characters of the section: see key, p. 287. The only species known is the circumpolar *X. parasiticus* (Bull. *ex* Fr.) Quél. Massachusetts material (*D. H. Linder & R. Singer*, Greenwood, Sept. 1943), and Paris material (R. Singer, Bois de Meudon, Aug. 1935) show the following chemical characters: **KOH** and $\mathbf{NH_3}$ on surface of pileus and on the yellow context

castaneous; **NH_4OH** on surface of pileus castaneous, eventually paler but with darker ring; **HNO_3** on surface of pileus castaneous, eventually with a bright orange ring; **$FeSO_4$** negative. The trama of alcohol-material from Middlesex Fells, Mass., shows an undifferentiated mediostratum, the outer larger part of the trama diverging but only slightly so, the non-diverging portion rather more hyaline than the diverging one, the latter of rather densely arranged hyphae without clamp connections; both strata continuing around the bottom of the tube. The inverse coloration of the tramal strata as compared with the *Boletus*-type may be due to the preserving medium. In the same material some 1.5 mm. broad and 4.5 mm. high primordia have been sectioned by the author since they represented the youngest stage in which the beginning hymenophore could still be demonstrated. These primordia showed the presence of a distinct ring-hole which is in apparent contradiction to previous statements in the literature. I am at a loss to explain these facts unless the ring-hole in our preparations is also due to an alternating influence on the tissue caused by the preserving fluid. *X. parasiticus* has not yet been found in Florida, notwithstanding the abundance of its hosts, *Scleroderma* spp., in the state.

Sect. **Brasilienses** Sing. sect. nov.

Pileo tomentoso et viscido; poris initio parvulis, deinde amplis vel pro ratione amplissimis; sporis exiguis (6–9.3 x 2.8–4.2 μ); trama typi *Phyllopororum*; in tropicis et subtropicis.

Characters of the section: see key, p. 287 and the above Latin diagnosis.

16. **Xerocomus brasiliensis** (Rick) Sing. comb. nov.

Boletus brasiliensis Rick, Ann. Mycol. **3**:235. 1905.

Pileus pale or light yellow, felty tomentose and at the same time viscid, sometimes with narrow sterile margin, hemispheric to convex, 10–20 mm. broad, rarely broader. — *Hymenophore* greenish yellow, slightly depressed around the stipe, tubes of medium length, pores concolorous, wide when mature, inequal, irregular; spore print not obtained but judging from small deposits on the carpophore itself, probably olive brown. — *Stipe* pale melleous to yellow, smooth or almost so, sometimes mealy on top, solid, cylindric, about 21 x 3–5 mm., rarely larger. — *Context* subconcolorous with the surface, unchanging, odor none.

Spores 6–9.3–(10) x 2.8–4.2 μ, mostly around 8.5 x 3.5 μ with 0.4 μ thick wall, smooth, melleous, subellipsoid-cylindric or somewhat variable in shape; *basidia* (13)–19–28 x (4)–6.5–8.8 μ, 4-spored with 4.5 μ long sterigmata; *cystidia* inconspicuous and infrequent, hyaline, not or very little incrusted, fusoid-ampullaceous, *e.g.* 17.5 x 5.5 μ; *trama* very homogeneous, rather hyaline, of almost equal density and without an appreciably darker colored zone in the middle, of the *Phylloporus*-type; *cuticle* of the dried material available not showing any particular structure; *laticiferous vessels* present, melleous, all *hyphae* without clamp connections.

Chemical reactions: **KOH, NH_4OH, NH_3** everywhere brown.

Habitat: On the ground in open places and in dense subtropical woods (low hammock type) on humus and débris, even up to two feet on the living trunks of trees, never near conifers, solitary or in small groups, in Florida fruiting in August.

Distribution: Florida (rare), Brazil (frequent). Exact limits unknown.

Material studied: **Fla.** Highlands Co., Highlands Hammock State Park, *R. Singer, F 641* (FH); **Brazil:** Near São Leopoldo, numerous specimens including parts of the **type** and **authentic** material in Rick: *Fungi Austroamericani, 1909* (FH).

The above description proves that this is a *Xerocomus*, and not related to *Boletus fulvidus* (*i.e. Gyroporus castaneus*) as suspected by Rick. This small and inconspicuous bolete has not been found, and, for that matter, not been looked for in the West Indies and northern South America.

Sect. **Pseudoboleti** Sing. sect. nov.

Pileo viscidulo at subtomentoso; tramate structura intermedia inter typum *Phylloporum* et typum *Boleti* gaudente; vaporum ammoniacalium ope brevissime caerulescente-nigrescit; in silvis coniferis borealibus.

This is the section for the species with intermediate tramal structure that cannot easily be linked with any group within the genus *Boletus*, *sensu str.* In the type and only species, *X. badius* (Fr.) Kühn. *ex* Gilbert (*Boletus badius* Fr.) the subhyaline lateral stratum is slightly looser than the mediostratum and its hyphae moderately but distinctly divergent, touching each other and somewhat broader than in the mediostratum where the hyphae are regular-subinterwoven and somewhat (very pale) colored. The spores are in some specimens within the usual limits in *Xerocomus*, in others larger. Coker and Beers suggest that the American *X. badius* has the spores smaller than the European type. However, material collected by me near Lynnfield, Mass. (FH) has the spores 11.5–18.5–(24) x 4–5 μ, and material from Austria (FH) has them 12.5–16.5 x 5–5.7 μ. Some authors consider *X. badius* as a *Suillus* but aside from the habitat, and the subviscid pileus there are no other characters to support this view. The blackish-blue flush with ammonia on the surface of the pileus would rather support Gilbert's proposal to consider it as a *Xerocomus*. It has not been observed in Florida.

SPECIES INCOMPLETELY KNOWN

Xerocomus Boudieri Sing., Ann. Mycol. **40**:43. 1942.

This species has not been studied thoroughly enough to decide whether it belongs in *Xerocomus* as redefined in this paper. The same is true for *Boletus Roxanae* and *B. innixus* Frost (at least authentic material at FH) which evidently are very close to *X. Boudieri* if not identical. Neither of these three species has been observed in Florida.

Xerocomus lignicola (Kallenbach) Sing., Ann. Mycol. **40**:43. 1942.

Boletus lignicola Kallenbach, Pilze Mitteleur. **1**:57. 1929.

With the data at hand, I am unable to decide whether this is a *Xerocomus* spec. or a form of *Phlebopus sulphureus* (Fr.) Sing. (*Boletus sulphureus* Fr.).

Xerocomus tumidus (Fr.) Gilbert, Bolets, p. 145. 1931.
Boletus tumidus Fr., Hym. Eur., p. 501. 1874.

Fries' species is dubious as its author states himself. Gilbert bases his treatment on Peltereau's emendation but this also is insufficient for generic determination.

SPECIES EXCLUDENDAE

Xerocomus amarellus Quél. is *Suillus piperatus* var. *amarellus* (Quél.) Sing.
Xerocomus gentilis (Quél.) Sing.

This is treated as *Pulveroboletus gentilis*. The same disposal is made of *Xerocomus auriporus* (Peck) Sing. and *X. flaviporus* (Earle) Sing. In fact, the entire section *Auripori* has been transferred to *Pulveroboletus*.

Xerocomus griseus (Frost) Sing.=*Boletus griseus* Frost.

The section *Grisei* has been reunited with *Boletus*.

Xerocomus impolitus (Fr.) Quél. is *Boletus impolitus* Fr.
Xerocomus mirabilis (Murr.) Sing. is *Boletellus mirabilis* (Murr.) Sing.

The section *Mirabiles* has been transferred to *Boletellus*.

Xerocomus pulverulentus (Opat.) Gilbert.

This species is here retransferred to *Boletus*. *Xerocomus radicans* (Pers. *ex* Fr.) *sensu* Quél. (*non* Kallenbach) is the same.

Xerocomus rubellus (Krombh.) Quél. is here treated as *Boletus*.

Xerocomus chrysenteron var. *versicolor* Quél., *X. armeniacus* Quél., *X. pruinatus* (Fr.) Quél., and *X. versicolor* (Rostkov. *non* S. F. Gray) Gilbert are forms of the same species. In this country, *Boletus bicolor* Peck and *B. fraternus* Peck belong in the same complex, but they have never been considered as *Xerocomi*.

Xerocomus sulfureus (Fr.) Quél. is *Phlebopus sulphureus* (Fr.) Sing.
Xerocomus spec. Heim, Bol. Soc. Broter. **13**(2):53. 1938 is *Boletochaete* spec.
Xerocomus spec. Snell *apud* Slipp & Snell, Lloydia **7**:50. 1944 is *Boletus* spec.

EXPLANATION OF PLATE I

All drawings of spores are at a magnification of × 2000; all other drawings of microscopic structures at × 1000; figs. 5–7 shown at natural size.

Fig. 1–4. *Gyroporus purpurinus* (Snell) Singer

1. Structure of the cuticle of the pileus.
2. Cheilocystidia of the hymenophore.
3. Basidium.
4. Spore.

Fig. 5–7. *Boletinus decipiens* (B. & C.) Peck

5. Gasteromycetous conditions of the carpophore sketched at natural size.
6. Longitudinal section of an immature carpophore (natural size). The veil closely applied to the surface of the hymenophore.
7. Longitudinal section of a mature carpophore (natural size), the remnant of the veil remaining as a relatively closely attached annulus.

Fig. 8–10. *Suillus cothurnatus* ssp. *thermophilus* Singer

8. Part of the hymeniform fragments on the surface of the stipe that are found in and around the glandular dots.
9. Large dermatocystidia, another element of the glandular dots of the stipe.
10. Spore.

Fig. 11–12. *Phylloporus rhodoxanthus* ssp. *foliiporus* (Murr.) Singer

11. Spores.
12. Cystidia of the hymenophore.

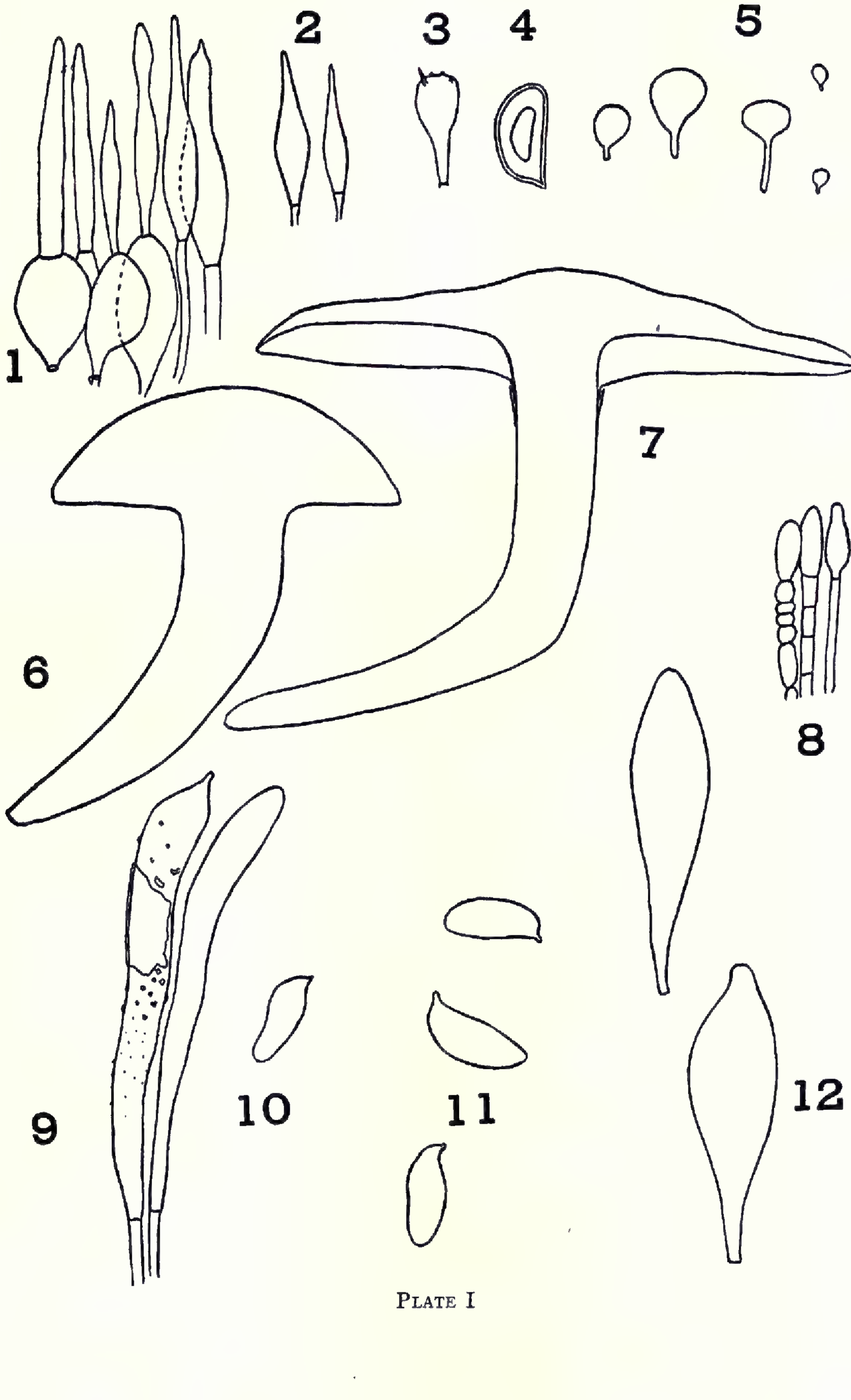

PLATE I

MANUSCRIPT

Contributions from anyone will be considered, preference being given to papers dealing with phases of the taxonomy of the Fungi, Algae, Musci, Hepaticae, and Lichens.

Contributors should strive for a clear concise style of writing. A limit of 100 printed pages is set for any one article, but it is hoped that a paper of such length will be so arranged as to be divisible in two approximately equal parts.

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CONTENTS OF VOL. 2, NO. 3

NOTE ON ARGENTINE CHARAS. By *Roy M. Whelden* 305

NEW MOSSES FROM TIERRA DEL FUEGO. By *Edwin B. Bartram* 309

THE GENUS CUNNINGHAMELLA (MUCORALES). By *Victor M. Cutter, Jr.* . . . 321

A COMPARATIVE STUDY OF TORULOPSIS PULCHERRIMA AND TAPHRINA DEFORMANS IN CULTURE. By *Catherine Roberts* 345

THE CYPERICOLOUS AND JUNCICOLOUS SPECIES OF SCLEROTINIA. By *H. H. Whetzel* 385

Vol. 2, No. 2 was issued on September 17, 1945.

FARLOWIA

A JOURNAL OF CRYPTOGAMIC BOTANY

VOL. 2 JANUARY, 1946 NO. 3

NOTE ON ARGENTINE CHARAS

ROY M. WHELDEN

It may be conceded that the Charophyte-flora, even in those countries most thoroughly explored botanically, is none too well known. In countries such as Argentina, large in area and varied in climate, our knowledge is very much less, and is based almost entirely on incidental collections of the plants made by those who were primarily interested in gathering quite different material.

The scarcity of Charophyte-material is clearly indicated by the paucity of papers mentioning any such plants from Argentina. Alexander Braun (1882) mentioned *Chara foetida* A. Br. as occurring in that country, and referred to a form of *Chara Martiana* from there also. Spegazzini (1883) listed, as occurring there, ten species of these plants (6 *Nitella*, 1 *Lamprothamnus*, and 3 *Chara*, with several varieties and forms in addition), three being described as new species. It may be added that a few papers record the occurrence of additional species from the several countries bordering Argentina. All these suggest that despite the very small number of references to these plants they may be found to be of rather frequent occurrence there.

The present note results from the study of a small collection of five folders of the genus *Chara*, collected in October and November 1938, and January 1939, by W. J. Eyerdam, A. A. Beetle, and E. Grondona. As is not unusual with this group of plants, much of the material was received in a badly fragmented condition; however, species determination of all specimens was easily possible.

Three of the plants proved to be *Chara foetida* A. Br., noted above as occurring there. The condition of the specimens was such that determination of varieties or forms seemed inadvisable. Indeed the question might be raised as to whether the present state of knowledge of Charas is sufficiently ample to justify the establishment of too many varieties. Certainly casual examination of the three plants might lead to a conclusion that one had before him at least two species and perhaps a variety of one, making allowances for the immature condition of one of them. Yet in every particular — stem cortication, stipular crown, nature of branches, and fruit details — they closely resemble each other, varying only in the amount of incrustation, in the nature of the bracts, and more noticeably in the size of the specimens.

One of the two remaining folders was rather confusing on first examination, owing to the presence of two distinct species, *Chara Martiana* A. Br. and fragments of what seemed to be an atypical form of *Chara foetida* A. Br. The *Chara Martiana* was a male specimen.

The fifth folder contained a plant which proved to be a real puzzle. The plants were collected from "a still pond, in soft clay mud," and were noted to have "fruit very malodorous." The specimens (Fig. 1) were all small, the largest just over 10 cm. tall, of quite delicate appearance, and each of several slender spreading branches. The incrustation, present throughout the plant, was thin and inconspicuous, giving it a rather brownish-green color (dried specimens).

The stems are rather irregularly tripli-corticate (Fig. 3b), and 0.5–0.62 mm. in diameter, the primary cells usually slightly more prominent than the secondary. No spine cells occur, but only small internodal cells. The stipular crown (Fig. 3a) comprises a single row of rather irregularly arranged cells, twice the number of leaves at the node, each cell rounded or slightly elongate. Leaves 8–10 in a whorl, up to 1.3 cm. long, comprising 6–9 segments, the last of which is a very short, conical cell. Many leaves are completely ecorticate; in others, one, two, or the three lowest nodes may be corticated. The nature of the cortication (Fig. 2b) is in no way correlated with the node in which the leaf occurs, there occurring every conceivable variation from whorls of leaves all entirely ecorticate to those in which the lowest segments of every leaf are corticated. The bracteoles are likewise quite variable in number and in length, but occur only at the lower internodes, usually only on those bearing sporangia. Those subtending the sporangia are all cylindrical, with abruptly tapering ends, and may considerably exceed the sporangia in length. Those opposite the sporangia are much reduced, often to inconspicuous short conical cells. The antheridia, found only in the youngest leaves near the stem apex (Fig. 2c), are 280–320 μ in diameter; they are soon deciduous. The sporangia occur on the lower two to three internodes, and are 820–860(–900) μ long and 410–425 μ in diameter. The oöspores are dark brown, have 14–15 spiral ridges on the surface and are 600 μ long and 325 μ in diameter. The wall between the ridges is quite plane.

This plant has many points in common with *Chara Curtisii* T. F. Allen, *Ch. delicatula* Ag., *Ch. hydropitys* A. Br., and *Ch. leptopitys* A. Br. From all these it is set off by the absence of spine cells, by its poorly developed stipular crown of a single row of scarcely elongated cells, and by the nature of the cortication of the leaves. From other described Charas it is much more completely separate. It is therefore now described as a new species.

Chara leiopytis sp. nov.

Monoica, tenera et flexilis, leniter incrustata 10 cm. longa; caule 0.5–0.62 mm. in diam., triplo-corticatis, aculeis nullis sed cellulis verruciformibus; corona stipulari duplici foliorum numero, ex unica cellularum paullo elongatarum vel rotundatarum serie inaequaliter disposita; verticillis foliorum e foliis 8–10 compositis, 1.3 cm. longis, geniculis 6–9, articulis omnibus ecorticatis vel infimis 1–3 corticatis, corticatis ecortica-

tisque saepe in eodem verticillo; geniculis infimis bracteiferis, bracteis inaequalibus, longis cylindricis, apicibus conicis vel breviter conicis; antheridiis 280–320 μ in diam. mox caducis; sporangiis solitariis, oblongis, 820–860(–900) μ longis, 410–425 μ in diam.; oosporis 600 μ longis, 325 μ in diam., 14–15-gyratis, inter gyros planis.

Argentina: In stagnis ad argillam teneram, in Prov. Jujuy, Depto. San Pedro.

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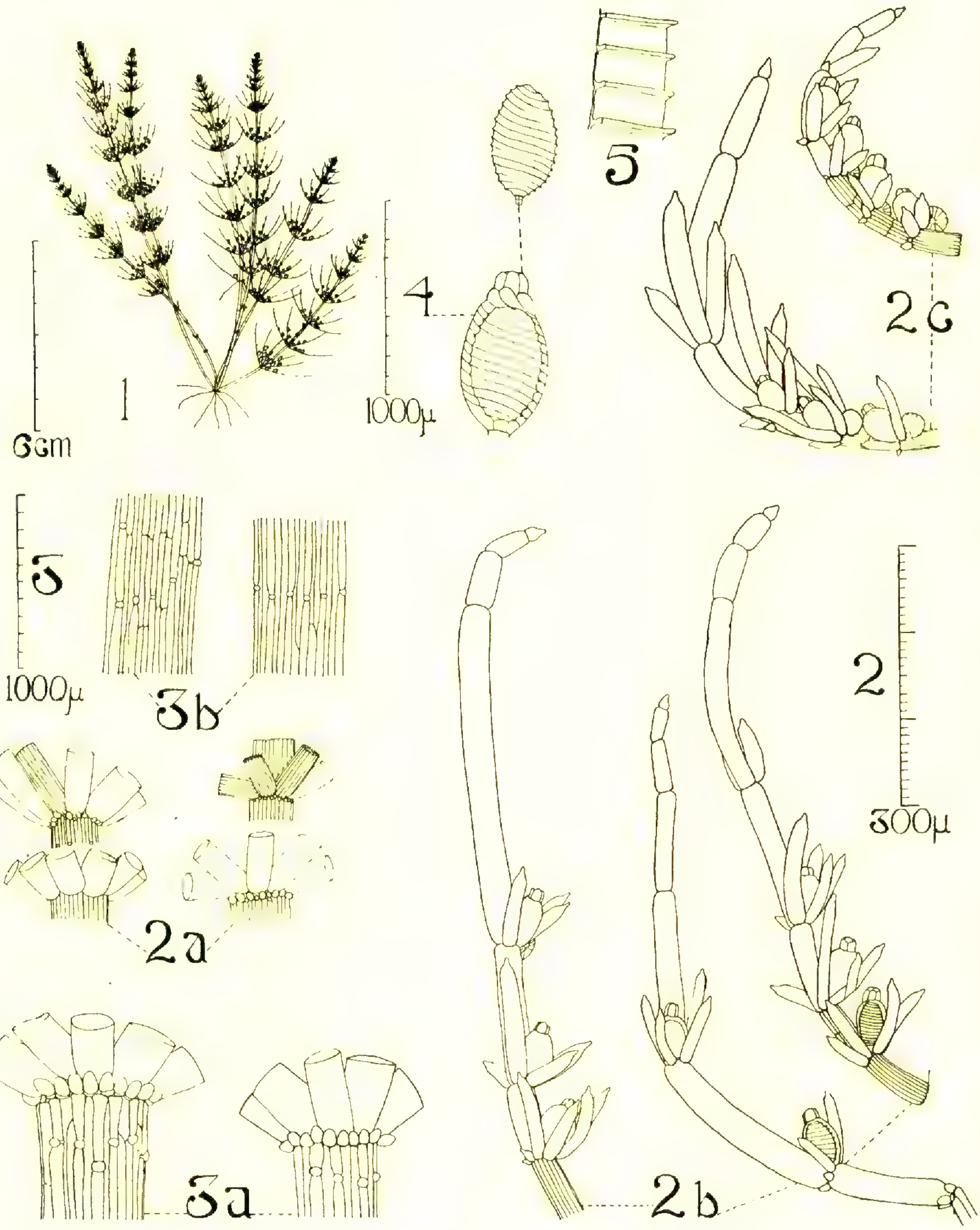
LITERATURE CITED

1882. **Braun, A.**. Fragmente einer Monographie der Characeen. Edited by O. Nordstedt. Abhandl. K. Akad. Wiss. Berlin **1882.** 211 pp. *7 pl.*

1883. **Spegazzini, C.** Characeae Platensis. Anal. Soc. Cient. Arg. **15:** 1–14.



Chara leiopytis Whelden n. sp.

Fig. 1. Habit of plant. **Fig. 2a.** Two illustrations of successive whorls, showing irregularities in branch corticications. **Fig. 2b.** Three branches showing irregularity of cortication, of node length, and of bracteoles. **Fig. 2c.** Two branches near apex of stem bearing antheridia. **Fig. 3a.** Two stem nodes showing stipular crown. **Fig. 3b.** Details of stem cortication. **Fig. 4.** Sporangium and oögonium. **Fig. 5.** Detail of wall of oögonium.

The magnification of each figure is given by an appropriately numbered scale.

2(3):309–319 FARLOWIA JANUARY, 1946

NEW MOSSES FROM TIERRA DEL FUEGO

EDWIN B. BARTRAM

About ten years ago I had the privilege of studying an extensive collection of mosses made by Dr. H. Roivainen in his capacity as botanist with the scientific expedition of the Finnish Geographical Society to Tierra del Fuego in 1928–29. All of the material was returned to Finland and subsequently I received a complete series of specimens including the types of many new species which resulted from the study, all of which are now in my herbarium.

In 1937 Dr. Roivainen published the results of his bryological investigations relating to Sphagnaceae, Andreaeaceae, Fissidentaceae, Ditrichaceae, Seligeriaceae and Dicranaceae.[1] This was to be followed by treatments of the succeeding groups but since then the unsettled conditions in Europe and especially in Finland have not only prevented further publications but have made it highly uncertain when, if ever, we may expect to have the remaining results of Dr. Roivainen's personal observations and studies. Meanwhile it seems advisable to record the descriptions of the new species, many of which are of the utmost interest.

DICRANACEAE

Chorisodontium sericeum Bartr. sp. nov.

Caespites densi, aureo-lutescentes, inferne fusci. Caulis ad 2 cm. altus, haud tomentosus, ramosus. Folia caulina circa 5 mm. longa, superne falcato-secunda, ovato-lanceolata, concava, sensim in acumen artistatum planum apice denticulatum attenuata; costa pallida, ad basin 50 μ lata, excurrente; cellulis alaribus distinctis, sequentibus linearibus, sinuosis, superioribus subquadratis vel oblongis. Folia perichaetialia e basi longe convoluta, subulata; seta 2.5 cm. longa, rubra, theca erecta, cylindrica; peristomium destructum. Caetera ignota.

Chile: Prov. de Magellanes, Isle Clarence, Puerto Beaubasin, ad saxa, No. 2297 **type.**

While similar to *C. lanigerum* (Besch.) Broth., this species seems to be constantly distinct in the flat, sharply toothed leaf tip, the narrower costa, and the stems almost devoid of either radicles or tomentum.

POTTIACEAE

Molendoa fuegiana Bartr. sp. nov.

Sat robusta, dense caespitosa, olivaceo-viridis, inferne fuscescens. Caulis circa 1.5 cm. altus, ramosus, inferne tomentosus, dense foliosus. Folia sicca contorta, madida arcuato-

[1] Roivainen, H. Bryological Investigations in Tierra del Fuego. Ann. Bot. Soc. Zool.-Bot. Fenn. Vanamo, **9**(2):v–x; 1–58. 1937.

patula, flexuosa, comalia stellata, ad 2.5 mm. longa, lineari-lanceolata, canaliculata, acuminata; marginibus erectis, undulatis, papilloso-crenulatis; costa valida, fusca, ad basin 100 μ lata, excurrente, mucronata, apice papillosa; cellulis superioribus rotundato-quadratis vel transverse dilatatis, chlorophyllosis, obscuris, dense papillosis, marginalibus hic illic bistratosis, inferioribus linearibus, rectangularibus. Caetera ignota.

Fuegia media: Lago Blanco, Puesto de los Indios, ad rupes, Nos. 162*a*, 163 **type,** 173.

As compared with the description of *M. boliviana* Broth. and *M. Herzogii* Broth. the leaves of *M. fuegiana* are appreciably longer while in *M. andina* Mitt. the leaves are narrower below and the upper leaf cells smaller and not transversely elongate.

Didymodon ampliretis Bartr. sp. nov.

Caespites compacti, virides, inferne fuscescentes. Caulis 1–1.5 cm. altus, pluries divisus, gracilis. Folia sicca parce contorta, humida erecto-patentia, ovato-lanceolata, canaliculata, sensim angustata, apice subobtusa; marginibus minute papilloso-crenulatis, medium versus anguste reflexis; costa valida, infra summum apice evanida; cellulis superioribus rotundato-quadratis, dense chlorophyllosis, obscuris, papillosis, marginalibus bistratosis, inferioribus rectangulis, pellucidis. Caetera ignota.

Fuegia media: Lago Fagnano, punta Pizzaro, ad rupes, No. 1217 **type;** Fuegia bor.: Estancia Esperanza, No. 427.

By comparison with *D. diaphanobasis* Card. of Mexico, the upper leaf cells of *D. ampliretis* are much more chlorophyllose and obscure while the basal cells are shorter with more firm, pellucid lateral walls.

Tortula robusta Hook. & Grev. var. **laxa** Bartr. var. nov.

Cellulis laminalibus laxioribus, 15–20 μ latis, grosse papillosis.

Fuegia media: Lago Linch, in silva paludosa, No. 189; Lago Linch, Cerro Chico, in reg. alp., No. 1357; Estancia Cameron, Puesto Medio, in prato humido, No. 1895 **type;** Fuegia occidentalis: Fjordo de Agostini, Bahia Groth Hansen, No. 254; Fjordo Martinez, ad rupes sericiticas, No. 583.

The collections referred here differ from typical *T. robusta,* as I understand it, in the large, lax, thin-walled cells of the upper lamina which are coarsely papillose with C-shaped papillae. The costa is smooth to papillose on the back. The leaves are narrower than those of *T. rivularis* Dus. and not as strongly serrate, while the cells are appreciably larger than in *T. pseudorobusta* Dus.

GRIMMIACEAE

Grimmia scabripes Bartr. sp. nov.

Autoica, caespitosa, sat robusta, fusco-viridis. Caulis prostratus, 3–4 cm. longus, ramosus. Folia caulina conferta, sicca appressa, humida erecto-patentia, ovato-lanceolata, concava, sensim in pilum hyalinum spinulosum attenuata, 2–3 mm. longa, 1 mm. lata; costa valida, in pilum producta, dorso papillosa; marginibus integris, toto fere longitudine late recurvis; cellulis superioribus rotundatis, altissime papillosis, hic illic bistratosis, margines versus 3–4 stratosis, inferioribus rectangularis, parietibus maximus incrassatis sinuosisque. Folia perichaetialia erecta, majora, costa angustiore; capsula immersa, breviter pedicellata, oblonga; peristomium aurantiacum, dentibus lanceolatis, integris; sporae lutescentes, laeves, diam. 8–10 μ.

Chile: Prov. de Nuble, Recinto, Las Trancas, ad truncos Nothofagi antarcticae, alt. 1150 m., No. 1003 **type.**

Readily distinguished from any of the forms of *G. apocarpa* and, in fact, from any of the species of the section *Schistidium* by the coarsely papillose leaf cells. A cross section of the leaf shows the papillae to the best advantage but they may be clearly seen in profile on the roll of the leaf without sectioning.

Rhacomitrium limbatum Bartr. sp. nov.

Robustum, dense caespitosum, nigrescens. Caulis erectus, ad 4 cm. altus, irregulariter divisus. Folia conferta, sicca erecta, parce flexuosa, humida patentia, 3.5–4 mm. longa, ovato-lanceolata, sensim acuminata, superne carinata, toto ambitu limbo lato incrassato circumducta; marginibus integris, inferne reflexis, superne planis; costa valida, excurrente; cellulis inferioribus linearibus, parietibus incrassatis, valde sinuosis, superioribus brevioribus, oblongis, costa versus bistratosis, margines versus 6–9 seriatis 3–4 stratosis. Seta 5–6 mm. longa; peristomii dentes rufescentes, ad basin divisi, papillosi; sporae papillosae, diam. 15–22 μ.

Fuegia occid.: Fjordo Finlandia, Brazo Aina, ad saxa, No. 502; Fjordo Martinez, ad rupes uliginosas, No. 594; Fjordo de Agostini, Bahia Groth Hansen, No. 2268; Chile: Prov. de Magellanes, Fuegia occid., Monte Buckland, alt. 500 m., Nos. 2084a, 2644; Isla Clarence, Puerto Beaubasin, ad saxa, Nos. 2313, 2316 **type.**

This exceedingly fine and interesting species is immediately distinguished from any of the forms of *R. crispulum*, and also from any member of the genus with which I am familiar, by the broad, fleshy leaf border extending from the apex almost to the insertion.

Rhacomitrium scabrifolium Bartr. sp. nov.

Robustum, aureo-lutescens. Caulis ad 8 cm. longus, irregulariter divisus, ramis breviter ramulosis. Folia 3.5 mm. longa, sicca erecta, humida erecto-patentia, ovato-lanceolata, plicata, superne canaliculata, sensim in pilum hyalinum denticulatum producta; marginibus papilloso-crenulatis, reflexis; costa depressa, angusta, ad medium folii evanida; cellulis omnibus elongatis, linearibus, papillosis, parietibus incrassatis, lutescentibus, valde sinuosis. Caetera ignota.

Chile: Prov. de Magellanes, Fuegia occid., Monte Buckland, alt. 500–700 m., No. 241; Puerto Yarton, Pico Nariz, reg. alp. No. 820; Fjordo Finlandia, Brazo Aino, No. 1970; Fjordo de Agostini, No. 2068 **type;** Bahia Sarmento, No. 2465.

The combination of plicate leaves and papillose leaf cells will separate this species from any of its Fuegian associates. In *R. ptychophyllum* Mitt. of New Zealand, the leaves are plicate but the short lateral branchlets are lacking and the leaf cells are smooth.

FUNARIACEAE

Funaria (Entosthodon) **pungens** Bartr. sp. nov.

Autoica, pusilla, gregaria, lutescente-viridis. Caulis 3–5 mm. altus, inferne radiculosus. Folia ovato-oblonga, acuminata, concava, comalia 2.5–3 mm. longa; marginibus integris, erectis, saepe ad basin uno latere inflexis; costa tenui, longe ab apice folii evanida;

cellulis superioribus oblongo-hexagonis, ad 50 μ latis, inferioribus rectangularibus. Seta erecta, rubella, ad 18 mm. longa; theca erecta, pyriformis; peristomium simplex, dentes rufi, papillosi; sporae fuscescentes, diam. 25–28 μ.

Fuegia occidentalis: Fiordo Martinez, Bahia Sarmento, No. 2358 **type.**

This species will be distinguished from *F. chiloensis* Mitt. by the sharply acuminate leaves and the broader and laxer areolation of the upper part of the leaf.

SPLACHNACEAE

Tayloria magellanica (Brid.) Mitt. var. **gigantea** Bartr. var. nov.

Caules 18–20 cm. alti, dense compacti.

This seems to be only an extremely robust form with densely tufted parallel stems, up to 2 dm. high, showing very clearly the zones of growth. The development is unusual and in this condition the plant is an exceptionally fine one.

Fuegia occidentalis: Fjordo Finlandia, prope Montem Nylandiam, No. 1745 **type.**

BRYACEAE

Mielichhoferia multiflora Bartr. sp. nov.

Synoica; flores plures stipitati. Caespites compacti, superne lutescente-virides, nitidi, inferne dense fusco-radiculosi. Caulis erectus, ad 2.5 cm. altus, dense julaceo-foliosus. Folia erecta, imbricata, ovato-lanceolata, acuminata, carinato-concava; marginibus erectis, superne denticulatis; costa valida, infra apicem folii evanida; cellulis anguste rhomboideis, basilaribus rectangularibus. Seta 8–10 mm. longa, lutescente-rubra; theca inclinata, asymmetrica; annulus latus; endostomium pallidum, corona basilaris humilis, processus angusti, linea divisurali distincti; operculum depresse conicum, apiculatum; sporae lutescentes, diam. ad 20 μ.

Chile: Prov. de Nuble, Cordillera de Chillan, alt. 2200 m., No. 1699 **type.**

In some respects the details of this species closely approximate the description of *M. leptoclada* C. M., but in *M. multiflora* the leaves are erect and closely imbricated and the segments of the endostome show a median line.

The numerous stalked flower buds are conspicuous and may be a good diagnostic character. While the fertile flowers are synoicous, the remaining undeveloped buds are often composed entirely of antheridia. Either the archegonia in these buds are abortive or the inflorescence is heteroicous.

Bryum (Cernuiformia) **Roivaineni** Bartr. sp. nov.

Synoicum; caespitosum, caespitibus densiusculis, sordide viridibus. Caulis ad 5 mm. altus, basi fusco-tomentosus, innovando-ramosus. Folia ad 3 mm. longa, ovata, acuta, haud decurrentia, concava; marginibus anguste recurvis, integris; costa crassa, fusca, infra apicem folii evanida vel percurrente; cellulis oblongo-hexagonis, firmis, basilaribus rectangularibus, concoloribus, marginibus elongatis, limbum biseriatum, fuscescentem efformantibus. Seta circa 2 cm. longa, rubra; theca nutans, oblongo-piriformis, sicca deoperculata, haud constricta; exostomii dentes fusco-lutei, endostomum sordide luteum, papillosum, processus angusti, exostomio adhaerens; sporae 18–22 μ in diam.

Chile: Prov. de Magellanes, Fuegia occid., Fjordo Finlandia, Brazo Aino, No. 2110 **type.**

This species seems to be distinct from both *B. austro-chilense* and *B. dicarpum* in the broader, less sharply pointed leaves and the thick, strong costa.

Bryum (Inclinatiformia) **fuegianum** Bartr. sp. nov.

Synoicum; gracile, caespitosum, caespitibus mollibus, pallide viridibus, inferne fuscescentibus. Caulis erectus, 2 cm. altus, gracilis, innovando-ramosus, innovationibus erectis, circa 2 cm. longis, base radiculosis. Folia sicca erecta, contorta, humida erecto-patentia, spathulata vel obovata, breviter acuminata, usque ad 3 mm. longa, 1.5 mm. lata; marginibus inferne reflexis, integris; costa infra apicem folii evanida vel percurrente; cellulis laxis, teneris, oblongo-hexagonis, basilaribus rectangularibus, rubris, marginalibus elongatis, limbum 3–4 seriatum efformantibus. Seta tenuissima, rubra, 5–6 cm. longa; theca nutans; exostomii dentes fusco-lutei; endostomium hyalinum, papillosum, processus angusti, superne dentibus adhaerens, cilia 0, sporae 25 μ in diam.

Fuegia media: Puesto Medio de la Estancia Cameron, in palude, No. 8 **type.**

Bryum (Cernuiformia) **austro-chilense** Bartr. sp. nov.

Synoicum; caespitosum, viridibus, inferne fuscescentibus. Caulis ad 1 cm. altus, basi fusco-tomentosus, innovando-ramosus. Folia sicca erecta, contorta, late ovata, breviter acuminata, carinato-concava, circa 1.5 mm. longa; marginibus anguste reflexis; costa fusca, percurrente; cellulis laxis, oblongo-hexagonis, basilaribus rectangularibus, concoloribus, marginalibus elongatus, limbum biseriatum efformantibus. Seta ad 2 cm. alta, rubra; theca nutans, pyriformis, 3 mm. longa; exostomii dentes fusco-lutei, apice hyalini, endostomium pallide luteum, processus angusti, superne dentibus adhaerens, cilia 0; sporae papillosae, 25 μ in diam.

Chile: Prov. de Nuble, Cordillera de Chillan, alt. 2000–2200 m., Nos. 1042, 1043, 1693 **type.**

Perhaps near *B. obscurum* Card. & Broth. but in comparison with the description of this species, the leaves of *B. austro-chilense* are smaller, the costa percurrent and the leaves of the innovations not comose at the tips.

Bryum (Cernuiformia) **dicarpum** Bartr. sp. nov.

Species precedenti forsan affinis sed costa infra apicem folii evanida, sporis majoribus et theca pendula, microstoma.

Synoicous; similar in habit and vegetative characters to *B. austro-chilense* but the leaves slightly larger, up to 2.5 mm. long with the costa ending just below the apex; setae constantly two from the same perichaetium; capsules pendulous, small-mouthed; spores 32–35 μ in diam.

Fuegia bor.: Hotel Bouqueron, in loco paludoso, No. 317 **type.**

Bryum (Inclinatiformia) **macrosporum** Bartr. sp. nov.

Dioicum; caespitosum, caespitibus densis, viridibus. Caulis erectus, 3–5 mm. altus, superne comoso-foliosus, inferne fusco-tomentosus. Folia comalia late oblongo-ovata, acuminata, carinato-concava, sicca erecta; marginibus integris, anguste reflexis; costa rubra, in aristam usque 300 μ longam, levem excedente; cellulis rhomboideis, basilaribus rectangularibus, rubris. Seta circa 2 cm. alta, rubra; theca pendula, 1 mm. longa, oblonga; exostomii dentes lutei, apice hyalini, endostomium hyalinum, processus

angusti, fenestrati, ciliis interpositis 3, parum brevioribus, haud appendiculatis; sporae lutescentes, papillosae, 30 μ in diam.

Chile: Prov. de Magellanes, Fuegia media, Lago Fagnano, Punta Pizzaro, No. 1211 **type.**

By the dioicous inflorescence this species is allied to *B. vernicosum* Dus. and *B. Hatcheri* Dus. but is distinct from both in the well-developed cilia of the inner peristome and the larger spores.

Bryum (Pseudotriquetra) **brachycarpum** Bartr. sp. nov.

Dioicum; caespitibus densis, pallide viridibus, intus fuscescentibus. Caulis erectus, innovando-ramosus. Folia ovata, breviter acuminata, limbata, ad 2.5 mm. longa; marginibus inferne anguste revolutis, summo apice minute denticulatis; costa inferne rubra, percurrente vel breviter excedente; cellulis rhomboideis, basilaribus oblongis, rubris, marginalibus elongatis, limbum 3–4-seriatum efformantibus. Seta 5–6 cm. longa, tenuis, rubra; theca pendula, 2.5 mm. longa, piriformis; cilia appendiculata; operculum convexum, apiculatum; sporae lutescentes, diam. 18–20 μ.

Fuegia media, Estancia la Marina, in palude, No. 677 **type.**

This species is apparently near *B. zeballosicum* Card. & Broth. but is clearly distinguished from this and any of the allied group by the much longer setae and the short, pyriform capsules with the neck only about half as long as the sporangium.

Bryum (Caespitibryum) **pauperculum** Bartr. sp. nov.

Dioicum; caespitosum, caespitibus densis, superne lutescenti-viridibus, intus fuscescentibus. Caulis vix 1 cm. longus, inferne fusco-radiculosus. Folia sicca appressa, humida erecto-patentia, triangulari-lanceolata, ad 2.5 mm. longa, sensim acuminata; marginibus fere ad apicem revolutis, integris; costa valida, in aristam laevem excedente; cellulis oblongo-hexagonis, basilaribus rectangularibus, rubris, alarabis laxis, marginalibus elongatis, limbum indistinctum efformantibus. Seta circa 2 cm. longa; exostomii dentes pallide lutescentes, endostomium hyalinum, papillosum, cilia appendiculata; sporae minutissime papillosae, fuscae, diam. circa 30 μ.

Chile: Prov. de Magellanes, Fuegia occid., Cabo San Pablo, Nos. 658 **type,** 670.

This species evidently stands in close proximity to *B. caespiticum* but the leaf outline is different, the margins and the arista are entire and the spores twice as large.

Bryum (Rosulata) **pseudothyridium** Bartr. sp. nov.

Dioicum; robustum, caespitosum, caespites densi, pallide lutescente-virides, nitidiusculi. Caulis erectus, dichotome innovans, dense rufo-tomentosus, ad 4 cm. altus. Folia ad apicem innovationem congesta, sicca erecta, flexuosa, spiraliter contorta, humida erecto-patentia, oblongo-obovata, apiculata, late limbata, ad 5 mm. longa; marginibus fere ad apicem revolutis, apicem versus remote denticulatis; costa crassa, basi rubella, in apiculum laevem excedente; cellulis ovato-hexagonis, basilaribus rectangularibus, infimis rubris, marginalibus linearibus, multiseriatis, limbum latum distinctum efformantibus. Seta ad 2.5 cm. longa, rubella, flexuosa; theca nutans vel pendula, oblongo-cylindrica, brevicollis, circa 3 mm. longa; operculum conicum, apiculatum; exostomii dentes fusco-lutei, apice hyalini, 0.6 mm. alti, endostomium pallide luteum, papillosum, corona basilaris alta, processus angusti, rimosi, cilia 3, valde appendiculata; sporae minute papillosae, diam. 12 μ.

Chile: Prov. de Magellanes, Fuegia occid., Puesto Yarton, loco uliginoso, No. 893 **type;** Fuegia media, Rio Bueno, Nos. 386, 1089.

An unusually handsome moss which is distinct from *B. Lechleri* C. M. and *B. andicola* Hook. in the more elongate and robust stems and the broad leaf border, up to 150 μ wide in the upper half of the leaf and composed of 8–15 rows of narrow linear cells.

BARTRAMIACEAE

Philonotis luteola Bartr. sp. nov.

Caespites compacti, pallide lutescente-virides. Caulis 5–6 cm. altus, inferne parce radiculosus, ramosus, ramis gracilis, laxifolius. Folia erecta, oblongo-ovata, breviter acuminata, haud plicata 2–2.5 mm. longa; marginibus planis, superne serrulatis; costa lata, male limitata, infra apicem dissoluta, dorso superne papillata; cellulis omnibus laevibus, laxiusculis, superioribus rhomboidalibus, inferioribus longioribus, marginalibus haud distinctis. Caetera ignota.

Fuegia media: Estancia Vicuna, Puesto 20, Cerro Fuentes, reg. alp., No. 734 **type.**

The unbordered leaves, broader costa and absence of any differentiated marginal cells at the basal angles will at once separate this species from any of the forms of *P. vagans*. It is distinguished from *P. acicularis* (C. M.) by the plane margined leaves and from both *P. varians* Card. and *P. parallela* Dus. by the costa ending below the apex.

Breutelia angustiretis Bartr. sp. nov.

Caespites densi, nitidi, superne lutescente-virides, inferne fusci, dense rufo-tomentosi. Caulis 4–5 cm. altus, irregulariter ramosus. Folia erecto-patentia, subflexuosa, e basi ovata, plicatula sensim longissime cuspidata, ad 4.5 mm. longa; marginibus integris, e basi anguste recurvis, superne planis; costa angusta, percurrente vel excurrente; cellulis omnibus anguste linearibus, laevibus, parietibus incrassatis, lutescentibus, infimis brevioribus, rubellis, parietibus sinuosis. Fructus ignotus.

Fuegia occidentalis: Fjordo Martinez, Bahia Pluschow, Nos. 592 **type,** 1136; Chile: Prov. de Magellanes, Isla Dawson, Puerto Valdez, in silva humida, Nos. 1326, 2563.

This species and *B. chrysura* (C. M.) Broth. are closely allied to *B. integrifolia* (Tayl.) Jaeg. A critical study of this group may show that the specific characters are too unstable to afford any practical basis for classification.

ORTHOTRICHACEAE

Macromitrium (Teichodontium) **coriaceum** Bartr. sp. nov.

Laxe caespitosum, lutescente-viride, intus fuscescens. Caulis repens, dense ramosus, ramis suberectis, usque ad 1 cm. longis, ramulosis. Folia sat densa, sicca erecta, contorta, humida erecto-patentia, lanceolata, plicata, breviter acuminata, superne carinata, 1.5–2 mm. longa; marginibus superne denticulatis; costa sub apice evanida; cellulis superioribus ovalis, incrassatis, laevibus, basilaribus anguste rectangularibus, valde incrassatis. Seta erecta, laevissima, 7–8 mm. longa; theca laevissima, oblongo-cylindrica, exothecio coriaceo; exostomium circa 30 μ altum, dentibus inter se concretis, papillosis, endostomium exostomio majus, processus 32, lati, obtusi, dense papillosi; calyptra nuda, laciniata; sporae papillosae, diam. 50–60 μ.

Chile: Prov. de Chiloe, Puerto Barroso de la Penins, Tres Montes, Nos. 1563, 1570 **type,** 1588, 1628.

Clearly distinguished from *M. Rusbyanum* E. G. Britt. and *M. macrosporum* Herz. by the longer segments of the inner peristome and the naked calyptrae.

LEMBOPHYLLACEAE

Camptochaete arbusculans Broth. *ex* Bartr.

Dioica; caespitosa, lutescente-viridis. Caulis sublignosus, bipinnate ramosus, ramis teretibus, saepe flagelliformiter attenuatis. Folia conferta, concava, imbricata, latissime ovata vel obovata, minute apiculata, 1.5 mm. longa, 1 mm. lata; marginibus erectis, superne denticulatis; costa variabilis, nunc simplex et fere ad medium folii producta, nunc brevis et binis vel nulla; cellulae anguste rhomboideae, laevissimae, apicales breviores, alares sat numerosae.

Chile: Prov. de Nuble, Recinto, Las Trancas, alt. 1200 m., No. 1600; Chile australis in montibus Cordillera de la Costa supra Angol oppidam in truncis arborum, Dusen No. 338, Nov. 11, 1896, **type.**

Roivainen's No. 1600 is exactly similar to Dusen's No. 338, issued as *Camptochaete arbusculans* Broth. which has been made available for comparison through the kindness of M. Theriot. The species is included by Brotherus in Ed. 2 of the Pflanzenfamilien but as the description seems never to have been published it may be validated by the above brief diagnosis.

The stem and branch leaves are not clearly differentiated. The leaves are very broadly ovate or obovate, minutely apiculate, alar cells rather numerous, upper cells small, parenchymatous, rhomboidal, median and lower cells narrower; margins erect, denticulate above; costa variable, short and double or even lacking, often single and extending nearly to mid-leaf. The variable costa is an anomalous character in *Camptochaete* but the plants are otherwise characteristic so I believe they may be included here under **Rigodiella** sect. nov. characterized as follows:

Folia caulina et ramea vix diversa; costa maxime variabilis, nunc simplex et bene evoluta, nunc binis et brevis vel nulla.

HOOKERIACEAE

Sauloma tenella (H. f. & W.) Mitt.

Fuegia media: Rio Bueno, in silva Nothofagi, No. 2008.

New to South America. The broad distribution of so many austral types which are common to New Zealand and the tip of the South American continent is again emphasized by the occurrence of this species in Fuegia.

AMBLYSTEGIACEAE

Hygroamblystegium: I think Reimers (Hedwigia **66:**71. 1926) is entirely justified in transferring the following species to *Hygroamblystegium.* They are certainly better placed here than in *Pseudoleskea.*

The group is a very intricate one and the distinctions so slight and inconstant that I doubt if they can be resolved into definite specific identities. The large series collected by Dr. Roivainen seems to be separable into two fairly distinct types as outlined in the tentative key presented below.

Leaves closely appressed
  Loosely tufted plants ..... **H. filum**
  Densely tufted plants, stems parallel ..... **H. filum** var. **compactum**
Leaves spreading or secund
  Habit rigid, leaves strongly secund, uncinate at tips **H. fuegianum** var. **secundum**
  Habit lax
    Costa short excurrent
      Very slender plants ..... **H. fuegianum** var. **gracilis**
      More robust plants
        Leaves erect-spreading or secund ..... **H. fuegianum**
        Leaves widely spreading ..... **H. fuegianum** var. **Skottsbergii**
    Costa long excurrent ..... **H. fuegianum** var. **excurrens**

Hygroamblystegium filum (C. M.) Reim.

Hygroamblystegium filum var. **compactum** Bartr. var. nov.

Caules elongati, ad 10 cm. longi, dense compacti, cellulae superiores breviter hexagonae.

Chile: Prov. de Magellanes, Fuegia media, Lago Linch, Cerro Chico, reg. alp., No. 1380 **type.**

An unusual form with long, parallel, densely tufted stems and short upper leaf cells.

Hygroamblystegium fuegianum (Besch.) Reim.

The following sporophyte characters are taken from No. 1016 which is in good fruit.

Seta slender, reddish, smooth, about 2 cm. long, twisted to the right when dry. Capsule cylindric, curved, constricted below the mouth when dry, urn 2 mm. long; peristome large, pale yellow; lid not seen; calyptra pale, early deciduous; spores smooth, 10–12 μ in diam.

Hygroamblystegium fuegianum var. **Skottsbergii** (Card.) Bartr. comb. nov.

Pseudoleskea fuegiana (Besch.) Card. var. *Skottsbergii* Card.

Hygroamblystegium fuegianum var. **excurrens** (Card. & Broth.) Bartr. comb. nov.

Amblystegium excurrens Card. & Broth.

Hygroamblystegium fuegianum var. **gracilis** (Card. & Broth.) Bartr. comb. nov.

Pseudoleskea fuegiana (Besch.) Card. var. *gracilis* Card. & Broth.

Hygroamblystegium fuegianum var. **secundum** Bartr. var. nov.

Caules rigidi. Folia saepe fortiter falcato-secunda.

Chile: Prov. de Magellanes, Fuegia media, Lago Fagnano, Punta Pizzaro, No. 1213 **type.**

Very different from any of the allied forms in the rigid, rather robust stems, uncinate at the tips and with the leaves clearly falcate-secund.

Calliergidium austro-stramineum (C. M.) Bartr. comb. nov.

Hypnum austro-stramineum C. M.

Dr. Grout (Moss Fl. N. Amer. **3**(2): 100. 1931) has advanced what seem to be adequate reasons for separating this group from *Drepanocladus*.

Calliergon sarmentosum (Wahlenb.) Kindb.

Very similar to the plants of the northern hemisphere in every way except that the apical leaves of the young branches and stems are more closely imbricated to form a terete tip ending in a cuspidate point.

BRACHYTHECIACEAE

Brachythecium longidecurrens Bartr. sp. nov.

Autoicum; lutescente-viride, nitidulum. Caulis irregulariter ramosus, ramis arcuatis. Folia dense conferta, scariosa, sicca imbricata, humida erecto-patentia, caulina e basi longe decurrente latissime cordato-ovata, in acumen breviusculum constricta, 1.5–1.7 mm. longa; marginibus inferne reflexis, superne planis, fere e base minute denticulatis; costa valida, ad 4/5 folii evanida; cellulis linearibus, inferioribus brevioribus et latioribus, alaribus rectangularibus, pellucidis. Folia ramea angustiora, sensim acuminata. Folia perichaetialia ecostata, in acumen patulum subito constricta; seta rubella, 2 cm. longa, superne scaberula; theca horizontalis, sicca arcuata, 1.5 mm. longa, fusca.

Chile: Prov. de Magellanes, Fuegia media, Rio Bueno, in silva, Nos. 2018 **type,** 2025, 2063.

These plants have something of the habit of *B. rivulare* Bry. Eur. but are immediately distinguished by the acuminate leaves, the longer costa, and the setae which are smooth below.

Brachythecium (Julacea) **micro-collinum** Bartr. sp. nov.

Autoicum; tenellum, pallide viride. Caules intertexti, depressi, irregulariter pinnati, ramis curvato-patulis. Folia minuta, sicca imbricata, humida erecto-patentia, concava, ovato-lanceolata, acuminata, haud decurrentia, circa 0.5 mm. longa; marginibus toto ambitu denticulatis; costa valida, ad 4/5 folii evanida, extremitate dentiformi; cellulis linearibus vel lineari-rhomboideis, basilaribus laxioribus, rectangulis, infimis ovalibus vel breviter rectangulis. Folia perichaetialia enervia, e base subvaginante in acumen abrupte constricta, marginibus ad basin integris, superne argute denticulatis; seta rubella, 6–7 mm. longa, laevissima; theca horizontalis, 1 mm. longa.

Chile: Prov. de Nuble, Recinto, in silva umbrosa, alt. 750 m., Nos. 954, 955 **type.**

Near *B. collinum* (Schleich.) but much smaller in every way and with a stouter, longer costa ending in a spine on the back. *B. arenarium* Card. & Broth. is described as having the stem leaves ending in a long, subulate acumen. This character, if constant, should preclude any confusion with *B. micro-collinum*.

PLAGIOTHECIACEAE

Plagiothecium nitidum (Hook. f. & Wils.) Bartr. comb. nov.

Leskea nitida Hook. f. & Wils.

I have outlined elsewhere (Manual of Hawaiian Mosses, p. 224. 1933) my reasons for thinking that *Catagonium* is a poorly defined genus. The above species does not appear to be generically distinct from *Plagiothecium*.

Calliergonella complanata Card. & Broth.

To judge from a fragmentary specimen of the type collection consisting of two stems and a few detached leaves which I have seen through the kindness of Dr. Linkola, is apparently one of the forms of *Eucatagonium politum* (Hook. f. & Wils.) with the leaves not clearly distichous.

SEMATOPHYLLACEAE

Sematophyllum aureo-nitidum Bartr. sp. nov.

Dioicum? Caespites depressi, sat densi, lutescente-virides, nitidi. Caulis ad 3 cm. longus, irregulariter ramosus. Folia conferta, falcata, e basi ovato-oblonga abrupte longe acuminata, ecostata, circa 2 mm. longa; marginibus planis, inferne integris, superne denticulatis; cellulis anguste linearibus, incrassatis, infimis lutescentibus, admodum porosis, alaribus 3–4, oblongis, vesiculosis, hyalinis vel lutescentibus. Folia perichaetialia ovato-oblonga, breviter acuminata; marginibus superne irregulariter denticulatis; seta rubella, laevissima, circa 12 mm. longa. Caetera ignota.

Chile: Prov. de Magellanes, Fuegia occid., Fjordo Martinez, ad rupes, No. 579; Fjordo Martinez, Bahia Sarmiento, No. 2351 **type.**

More robust than *S. callidum* (Mont.) Mitt. from which it also differs in the more glossy leaves hooked at the tips of the branches. The description of *Hypnum leucocytus* C. M. suggests something similar but Dixon remarks (Studies in the Bryology of New Zealand, Pt. VI, p. 309. 1929) that this species is not glossy while *S. aureo-nitidum* is characterized by a lustrous, almost metallic sheen.

POLYTRICHACEAE

Dendroligotrichum squamosum (Hook. f. & Wils.) Broth.

Numerous collections of this species show the end cells of the lamellae in cross section are either two-parted or single and the lamellae 4–5 cells high. The end cells have two lumens when two-parted and are scarcely suggestive of *Polytrichum commune* to which Dixon (Studies in the Bryology of New Zealand, Pt. IV, p. 235. 1926) indicates that it may have some affinity.

BUSHKILL
PIKE CO., PA.

2(3):321–343 FARLOWIA JANUARY, 1946

THE GENUS CUNNINGHAMELLA (MUCORALES)

VICTOR M. CUTTER, JR.

The opportunity has recently arisen to examine a number of isolates of *Cunninghamella* from various localities in North America. The confused synonomy and overlapping specific descriptions available in the literature have proved most troublesome in attempting to identify these isolates. It is the author's opinion that at the present time the accurate identification of species of *Cunninghamella* is practically impossible. This situation arises in large part from the failure of earlier workers to employ a standard reproducible culture medium in their studies, and in part from the fact that the known species have not yet been studied comparatively. Our expanding knowledge of the physiology and genetics of the fungi makes it evident that in such a plastic group as the Mucorales, specific concepts can be formulated only from isolates grown on rigidly standardized media under carefully controlled conditions. Descriptions based upon field collections and gross cultures are of little value to the mycologist interested in accurate determinations. Unfortunately for the advance of mycological science, the precision of technique employed by physiologists in their studies of growth and variation in fungi has too rarely been carried over into taxonomic investigations.

METHODS

In common with most fungi, *Cunninghamella* species are very sensitive to the most minute variations in the culture medium, and the same isolate grown upon different media may present a completely different aspect. This plasticity is no less evident at changing levels of temperature and humidity. Any key to this genus can be of practical value only when the material to be identified is handled under exactly comparable conditions. Therefore the standardization of cultural techniques is imperative, and towards this end the procedure described below is suggested as a standard to be followed in the identification of species of Mucorales. It is not claimed that the medium employed represents the best possible choice for cultural studies or maintenance of mucoraceous fungi. Rather the medium is designed to be easily and inexpensively reproduced and, when formulated with CP chemicals, to be as uniform as possible. To date approximately 150 species of Mucorales have been grown upon this medium with good results in all cases.

In connection with this procedure it is understood that all cultures should originate from single spores. This is easily accomplished, in the case of *Cunninghamella*, by any of the usual techniques. The medium used in this study is designated as M.D.A. agar and is made up according to the following formula, and adjusted to pH 4.2 with 0.1 N HCl.

dextrose	40.00 gr.	thiamine chloride	0.5 mgr.
asparagine	2.00 gr.	agar flakes	15.00 gr.
KH_2PO_4	0.50 gr.	distilled water	1000.00 cc.
$MgSO_4$	0.25 gr.		

All reagents used are of CP grade. The thiamine used is Merck's synthetic, the asparagine is Bacto-Difco, and the agar is Bacto-agar flakes prepared by the Difco laboratories.

In the routine of identification, isolates are grown upon M.D.A. agar at 25° C. and 40° C. Specific descriptions are based upon material cultured at 25° C. At the 40° C. level, cultures are recorded merely as growing or not growing. Smaller intervals of temperature than these have not proved practical for the sharp delimitation of species. No attempt is made to record degrees of growth since quantitative methods are rarely practical in a taxonomic treatment, and do not lend themselves to rapid identification.

Material for microscopic examination is mounted in a solution of equal parts of phenol crystals, lactic acid, glycerin and distilled water to which a detergent, "Tergitol" Penetrant 7, is added in the ratio of 3 drops per 50 cc. of solution. To this mixture 5 percent Sudan III is added, which furnishes an easy method of distinguishing chlamydospores and hyphal bodies from conidia since the former rapidly accumulate the stain whereas the latter remain unstained. The color of conidia and other spores is determined by mounting them in water.

In connection with conidial measurements in this genus a word of caution is necessary. The shape and dimensions of conidia can not be accurately determined until they are mature and have fallen from the vesicles. *In situ* their shape is frequently obscured or distorted by crowding, in most mounts only immature conidia remain attached to the vesicles, the mature conidia being readily deciduous. Many of the aberrant measurements found in the literature as well as the statements concerning supposed differences in size and shape of the conidia of the terminal and lateral vesicles are directly attributable to the failure to recognize this fact. The term "vesicle" is used here in reference to the capitate structure terminating the conidiophores after the conidia are detached. The age of cultures determines to some degree the type of branching displayed by the conidiophores and since cultures are rarely mature until six days after inoculation, all observations are made at this time.

Under the discussion of each species the original description is reproduced, followed by an emended description of the species based upon monospore cultures grown at 25° C. on M.D.A. agar six days after inoculation. The key to species is compiled from these emended descriptions. Technical color terms cited in quotation marks are those of Ridgway (26). The accession numbers given under the heading "material examined" refer to cultures and permanent mounts filed in the author's herbarium at Cornell University.

HISTORY OF THE GENUS

The genus *Cunninghamella* was established by Matruchot (18) in 1903 upon *C. africana* collected in the French Sudan. At this time he failed to provide a generic description which was later supplied by Saccardo (30). Thaxter (36) shortly pointed out that in reality *C. africana* only represented a redescription of his *Oedocephalum echinulatum*, and that the species should therefore be known as *C. echinulata*. Matruchot had postulated that in spite of its purely conidial reproduction in the asexual phase, *Cunninghamella* should be placed in the Mucorales, and supported his claim with a series of ingenious experiments showing that *Cunninghamella* will serve as a host for species of *Piptocephalis* which are parasitic exclusively upon the Mucorales. He further indicated that the usually aseptate mycelium favored the inclusion of *Cunninghamella* in this group. His opinion was subsequently confirmed by Blakeslee (5) who discovered the zygospores of *C. echinulata* in 1904. In the following year Saito (31) described the genus *Actinocephalum* based upon *A. japonicum*. Fitzpatrick (11) has pointed out that this genus is undoubtedly synonymous with *Cunninghamella*. In 1907 Lendner (14) described *C. elegans* in Swiss soil, and later, in 1927, he (16) described *C. Blakesleeana* from North American material sent to him by Blakeslee. Stadel (32) in 1911 founded *C. Bertholletiae* upon a strain from decaying Brazil nuts, and discussed certain aspects of its growth and development upon various substrates. Shortly thereafter Bainier & Sartory (2), apparently unaware of the existence of *Cunninghamella*, erected the genus *Muratella* upon *M. elegans* collected in France. Torrey (37) showed that this species was synonymous with *Cunninghamella echinulata* Thaxter, and investigated the development and morphology of the conidia in some detail. Naumov (20), however, on the basis of its consistently spherical conidia, considered *Muratella elegans* distinct from *Cunninghamella echinulata* and erected the new combination *C. Bainieri* to include it and several of his own isolates. Ling-Young (17), on the other hand, considered *Muratella* with its curious giant conidia to be distinct from *Cunninghamella* and maintained it as a valid genus.

Paine (22) in 1927 described *C. verticillata* from the United States. This species has been reported several times subsequently, but appears to be synonymous with *C. Blakesleeana* Lendner, which had been described and published three months before. Pišpek (23) in 1929 discussed a series of isolates from Yugoslav soils and erected four new species, *C. ramosa*, *C. dalmatica*, *C. polymorpha* and *C. echinata*. None of these species has been subsequently reported and all of them seem conspecific with previously described forms, although Pišpek's meager descriptions make positive identification uncertain. In 1930, Fitzpatrick (11) briefly summarized the work on *Cunninghamella* to that date. Zycha (38) in 1935 presented the first comprehensive survey of the genus and the first key to the species. He retained the six following species: *C. microspora*, *C. albida*, *C. elegans*, *C.*

ramosa, *C. Blakesleeana* and *C. echinulata*, and presented descriptions of these compiled from the literature. All other described species were reduced by him to synonomy. This treatment has served as a standard for most subsequent work. Alcorn and Yeager (1) in 1938 published a monograph of the genus with emended specific descriptions of species collected by them in Idaho. This work contained a key to the species based in part upon the literature and in part upon their own observations, as well as numerous inaccuracies in the translations of original descriptions. While their monograph purports to cover the entire literature on *Cunninghamella*, in reality a number of species are not treated, in particular those of Pišpek and of Zycha. The latest treatment of the genus is that of Naumov (20) in 1939. He presents a descriptive key to all the known species compiled from the original descriptions and his own observations. He retains all the previously described species and erects the new combination *C. Bainieri* to include *Muratella elegans*. He has stated that this key is only tentative and the future studies will show that many of these species are not valid.

Our knowledge of the sexuality of this genus and of the zygosporic stages is largely confined to the works of Blakeslee (6), Burger (9) and Blakeslee, Cartledge and Welch (7). The last named authors have shown that *C. elegans*, *C. Bertholletiae*, *C. Blakesleeana* and *C. echinulata* are heterothallic forms and are sexually dimorphic, a conclusion contrary to that advanced by Burger on the basis of experiments with *C. Bertholletiae*. Blakeslee (6) had previously described and figured the zygospores of *C. echinulata*, and Lendner (16) supplied the same information for *C. Blakesleeana*. The sexual stages of other described species are as yet unknown. All these authors have indicated that zygospore formation is usually initiated at temperatures above 25° C.

The systematic position of *Cunninghamella* has been treated in various ways by different authors. Matruchot (18) considered it to belong in the tribe Choanephoree in company with *Choanephora*. Lendner (15) places it in the family Chaetocladiaceae in the suborder Conidiophorae. Fitzpatrick (11), Zycha (38), Christenberry (10) and Ou (21) place it in the family Choanephoraceae, with *Blakeslea* and *Choanephora*. However, Naumov (20) creates the family Cunninghamellaceae to include *Cunninghamella*, *Thamnocephalis* and *Sigmoideomyces*. At the present state of our knowledge the latter disposition seems most natural since this group of genera forms a coherent unit well separated from *Choanephora* and *Blakeslea* by the complete absence of sporangia and the presence of echinulate globose conidia. Furthermore, the dark colored rough-walled zygospores set *Cunninghamella* apart from *Blakeslea* and *Choanephora*, which have thin-walled, smooth, more or less hyaline zygospores.

It must be pointed out in connection with the validity of the name *Cunninghamella* that this genus was founded upon the conidial or imperfect stage of *C. africana* by Matruchot in 1903. The perfect stage (i.e. the zygospores) was not discovered until 1904 by Blakeslee who described the

zygospores in *C. echinulata*. These two species are synonymous. If the strictest interpretation of the International Rules of Botanical Nomenclature is followed (i.e. Art. 57) *Cunninghamella* must be attributed to Blakeslee, who, however, failed to give a generic description with his report of the perfect stage of this fungus. On the other hand the International Rules fail to define exactly what constitutes the perfect stage of a Phycomycete of the mucoraceous type. Under proper conditions in homothallic species, and in the case of heterothallic species such as *Cunninghamella*, in the presence of two compatible strains, the gametangia and zygotes are borne upon the same mycelium which gives rise to the asexual reproductive structures. Since the perfect and imperfect stages are thus inextricably mingled it will be seen that while these fungi are pleomorphic in regard to their life cycle, there is no certain way of separating the two stages for taxonomic purposes. This situation is somewhat different from the case of certain heterothallic Ascomycetes and Basidiomycetes having pleomorphic life cycles where the perfect and imperfect stages are clearly distinguishable. Bisby (4) has pointed out other instances where the strict application of Article 57 to the Phycomycetes creates nomenclatural problems of this nature. In the Mucorales dogmatic adherence to this rule would necessitate a large number of changes in the author citations, and redescription of genera and species, because the great majority of forms have been described in their imperfect stages. Consequently in this and subsequent work on the Mucorales, Bisby's suggestions will be followed, and the first valid name applied to genus or species will stand irrespective of whether it was applied in cases where the zygotic stage was not known or described.

Cunninghamella Matruchot, Ann. Mycol. **1:** 47–50. 1903; — Saccardo, Syll. Fung. **17:** 508. 1905.
Actinocephalum Saito, Bot. Mag. Tokyo **19:** 1. 1904.
Saitomyces Ricker, Journ. Mycol. **12:** 61. 1906.
Muratella Bainier & Sartory, Bull. Soc. Mycol. France **29:** 129. 1913.

Fungi with erect or ascending conidiophores, abundant submerged sterile mycelium, aseptate when young, becoming septate in age, hyaline or light colored. Conidiophores variously branched or sometimes simple, each branch terminating in a capitate vesicle covered with minute sterigmata bearing conidia. Conidia unicellular, globose to ellipsoid, echinulate, asperulate, or smooth, deciduous. Sporangia absent. Chlamydospores occasionally present, intercalary, spherical to ellipsoid with granular or oily contents. Rhizoids present in some species at base of conidiophores or indiscriminately arranged on aerial parts. Gametangia isogamous. Zygospores globose or doliform, dark-walled, tuberculate or roughened. The known species are heterothallic and saprophytic on a wide variety of substrates.

The type species is *Cunninghamella echinulata* (Thaxter) Thaxter.

KEY TO THE SPECIES OF CUNNINGHAMELLA

1. Growing at 40° C. ..... 2.
   2. Colonies "Smoke Grey"; branches of the conidiophores sympodial, cymose or irregular, not verticillate; conidia predominantly spherical with long echinulations; giant conidia absent. .....1. **C. echinulata.**
   2. Colonies "Gull Grey," branches of the conidiophores verticillate; conidia predominantly ovoid to ellipsoid with short echinulations. ...4. **C. Bertholletiae.**
1. Not growing at 40° C. ..... 3.
   3. Giant conidia present; colonies "Smoke Grey" to "Pale Olive Buff"; conidia predominantly spherical with long echinulations or sometimes smooth. 2. **C. Bainieri.**
   3. Giant conidia absent; conidia predominantly ovoid to ellipsoid with short echinulations. ..... 4.
      4. Colonies "White"; branches of the conidiophores dichotomous, sympodial or verticillate; rhizoidal tufts apparent macroscopically; conidia up to 35 x 25 μ. 3. **C. Blakesleeana.**
      4. Colonies "Gull Grey"; branches of the conidiophores always verticillate; conidia up to 16 x 12 μ; rhizoidal tufts not apparent macroscopically. ..... 5.
         5. Chlamydospores usually present; mycelium containing much oil; habitat Brazil nuts. .....4. **C. Bertholletiae.**
         5. Chlamydospores absent; mycelium mostly lacking oil; habitat soil and seeds. 5. **C. elegans.**

1. **Cunninghamella echinulata** (Thaxter) Thaxter, Rhodora **5:** 98. 1903.
   Oedocephalum echinulatum Thaxter, Bot. Gaz. **16:** 17. 1891.
   Cunninghamella africana Matruchot, Ann. Mycol. **1:** 47–50. 1903.

PLATE I, A–I

"White becoming slightly yellowish. Sterile and fertile hyphae not clearly differentiated, the latter more or less irregularly and indefinitely branched. The fertile heads nearly spherical to obovoid, very variable in size, more or less distinctly areolate: maximum 45–65 μ: average 28–35 μ. Spores oval to elliptical, finely echinulate: average 10 x 12 μ; maximum 18–25 μ." — Thaxter (1891).

On M.D.A. agar:

Colonies up to 1.5 cm. high, spreading rapidly, "Smoke Grey," powdery in appearance; growing at 40° C. *Sterile mycelium* smooth-walled, much-branched, mostly aseptate, up to 20 μ in diam.; rhizoids occasional; *chlamydospores* occasional upon submerged portions, irregular in shape and size. *Conidiophores* dichotomously or cymosely, never verticillately, branched; each branch terminated in a swollen vesicle, broadly clavate to subspherical, up to 60 μ in diam., average 25–40 μ in diam.; smooth or faintly areolate, no conspicuous difference in shape of lateral and terminal vesicles. *Conidia* globose to ovoid up to 20 x 18 μ, average 11–14 μ in diam., thickly beset with very fine spines up to 4 μ in length, the immature conidia sometimes smooth. *Zygospores* described by Blakeslee (6) and not subsequently reported. Gametangia isogamous or heterogamous; zygospores nearly opaque, 46–80 x 40–63 μ, average 70 x 58 μ, thickly beset with long heavy tubercles. Zygospore formation taking place only at temperatures above 25° C.

TYPE LOCALITY: On cheese and cheesy paper, Massachusetts. Thaxter.

DISTRIBUTION: Camel dung, French Sudan, 1903, Matruchot; dried flowers, Venezuela, 1905, and Puerto Rico, 1905, horse dung, Philippines, 1905, Blakeslee; Brazil nuts and soil, (18 races), New York, 1921, Blakeslee, Cartledge & Welch; soil, Dalmatia, 1932, Johann; soil, Bastrop Co., Texas, 1932, Morrow; soil, Cuba, South Carolina, North Carolina, Louisiana, 1940, Christenberry; decaying flowers of *Cucurbita pepo*, Szechuan, China, 1940, Ou.

MATERIAL EXAMINED: Panama, C. Z., date and substrate unknown, *Weston* (Acc. no. 110); locality unknown, via Harvard Cult. Coll. (Acc. no. 127); Ontario, peas, 1941, *Groves*, (Acc. no. 152); Arnprior, Ont., peas, 1943, *Groves*, (Acc. no. 294); Ithaca, N. Y., contaminant in culture, 1943, *Cutter*, (Acc. no. 345); locality unknown, from Brazil nuts, *Blakeslee*, (Acc. nos. 374, 375); locality, date and substrate unknown, *Blakeslee*, (Acc. nos. 376, 377, 378, 379).

The type of branching is the most important character separating *C. echinulata* from the other members of this genus. The descriptions and figures of Thaxter and Matruchot indicate that they were not dealing with a form having verticillately branched conidiophores. Plate I, A, B, D, and E shows the typical cymose branching encountered in vigorous cultures. In old cultures, pseudoverticillate conidiophores may be developed through the production of secondary conidiophores on the primary conidial head. A similar situation may occur if the conidiophores are submersed, as in the example shown in Plate I, G. This is, however, an abnormality. The author does not follow Zycha (38) in considering *Muratella elegans* Bainier & Sartory, and *C. verticillata* Paine as synonyms of *C. echinulata* inasmuch as these two forms are described and figured with verticillately branched conidiophores while a study of the present material of *C. echinulata* indicates that it is remarkably constant in its cymose branching.

Some slight discrepancies exist between Matruchot's description of *C. africana* and Thaxter's description of *Oedocephalum echinulatum*, chiefly in the dimensions of the conidial heads, which in *C. africana* are said to reach 100 μ in diameter. However according to Thaxter (36) the two forms are synonymous and in general the descriptions coincide well. Naumov (20) retains *C. africana* and makes *C. echinulata* a synonym of it, which is an untenable disposition when Thaxter's opinion that *C. africana* merely constituted a redescription of his *O. echinulatum* is considered.

Alcorn & Yeager's description of *C. echinulata* contains the statement that the vesicles are areolate, an opinion which probably arises from a liberal interpretation of Thaxter's more cautious statement that the heads are sometimes faintly areolate. In the cultures studied here the areolate condition could sometimes be discerned but it certainly was not present in the majority of isolates and it was usually characteristic only of immature vesicles.

C. echinulata is the only species of *Cunninghamella* which in this study consistently showed growth at temperatures above 40° C. This characteristic, and the absence of the peculiar giant conidia described below, distinguish it clearly from the following species.

2. **Cunninghamella Bainieri** N. Naumov, Clés des Mucorinées, Paris, 1939.
Muratella elegans Bainier & Sartory, Bull. Soc. Mycol. France **29:** 9. 1913.
Muratella sp. Ling-Young, Rev. Gen. Bot. **42:** 744. 1930.

PLATE I, J–O

"Conidia all spherical 14–17 μ in diam. armed with bristles 2 μ in length; sterigmata 0.5–1.4 μ long; colonies dirty white, 1 cm. high or more; verticils of 3–8 elements, accompanied as well by longer branches of the conidiophores; swellings of 28–58 μ in diam." Naumov.

On M.D.A. agar:

Colonies 0.5–3 cm. high, "Pale Olive Buff" to "Pale Smoke Grey," powdery in appearance, not growing at 40° C. Sterile mycelium much-branched, up to 30 μ in diam., aseptate when young, in the submerged portions frequently swollen into vesicular shapes; true chlamydospores absent. Conidiophores erect, usually verticillately branched below the terminal head, sometimes with several whorls of branches, lateral branches usually less than 50 μ long. Vesicles up to 60 μ in diam., average 40 μ, lateral vesicles usually smaller than the terminals. Vesicles bearing normal conidia generally smooth, sometimes verrucose when young, vesicles bearing giant conidia markedly verrucose. *Conidia* of two sorts, predominantly spherical, sometimes broad ovoid; normal conidia hyaline 5–15 μ in diam. with slender sharp echinulations up to 3.5 μ long, giant conidia yellow to brownish, thick-walled, 15–27 μ in diam. with stout sharp echinulations up to 2 μ long or sometimes smooth, giant conidia usually borne on verrucose subterminal vesicles developing in older portions of the colony. *Zygospores* unknown.

TYPE LOCALITY: Dead wood, France, Bainier & Sartory, 1913.
DISTRIBUTION: Soil, France, 1930, Ling-Young.

MATERIAL EXAMINED: *Hibiscus* flowers, Ann Arbor, Mich., 1940, *Cutter* (Acc. no. 29); locality and substrate unknown, 1942, via American Type Cult. Coll. (Acc. nos. 348, 352, 354); locality, date and substrate unknown, C. B. S. via Blakeslee (Acc. nos. 386, 387).

This species, which is closely related to *C. echinulata*, may be easily distinguished by the presence of numerous giant conidia in older cultures, as well as by its failure to grow at 40° C. Bainier & Sartory (2) give its optimum temperature range as 25–27° C. Ling-Young (17) has discussed the morphology of the "conidies tardives" or giant conidia, of this species, and states that they are always borne upon specialized lateral heads. This contention is not strictly borne out in the material studied here where the giant conidia are frequently interspersed with smaller conidia on both terminal and lateral vesicles. However, Plate I, N shows the usual condition where these structures are confined to certain lateral vesicles. A study of Ling-Young's illustrations show that they were based upon immature conidiophores which may account for the peculiar distribution of his "conidies tardives." These structures have not been encountered in other species of *Cunninghamella*.

3. **Cunninghamella Blakesleeana** Lendner, Bull. Soc. Bot. Geneva **19:** 234. May, 1927.

Cunninghamella "A," Blakeslee, Cartledge & Welch, Bot. Gaz. **72:** 185. 1921.
Cunninghamella verticillata Paine, Mycologia **19:** 253. Sept. 1927.
Cunninghamella echinata Pišpek, Acta Bot. Inst. Univ. Zagreb. **4:** 101. 1929.

PLATE II, A–D

"Conidiophores branched, terminated by swollen heads; heads minutely verrucose, 30 μ long by 28 μ wide, bearing ellipsoid conidia with finely echinulate walls. Branches of the conidiophore verticillate or solitary, lateral branches bearing spherical, hyaline to yellow conidia; zygospores spherical to doliform, dusky black, 40 μ in diam. up to 48 μ long by 49 μ wide." Lendner.

On M.D.A. agar:

Colonies 2 to 3.5 cm. high, spreading rapidly, "White," at maturity becoming tinged with yellow and compactly matted, not growing at 40° C. *Sterile mycelium* at first dichotomous, later irregularly branched up to 20 μ in diam., aseptate, bearing prominent tufts of rhizoids or outgrowths visible macroscopically upon the aerial portions, occasionally forming vesicular swellings containing much yellow oily material upon the submerged portions; true chlamydospores lacking. *Conidiophores* erect, sometimes dichotomously or sympodially but usually verticillately branched. Lateral branches of the conidiophores variable in length and number, usually less than 50 μ long. Vesicles variable, subglobose to broadly clavate up to 65 μ in diam., average 30–40 μ in diam., lateral vesicles usually smaller than terminal vesicles, verrucose to smooth. *Conidia* hyaline, predominantly ovoid to ellipsoid with smaller subspherical conidia interspersed, up to 35 μ long x 25 μ wide, average 5–18 μ long x 4–12 μ wide, with very short widely spaced echinulations or sometimes smooth. *Zygospores* not seen.

TYPE LOCALITY: Unknown.

DISTRIBUTION: Brazil nuts purchased at many localities in eastern U. S. A. (all nuts presumably from S. America), 53 races, 1921, Blakeslee, Cartledge & Welch; soil, Iowa City, Iowa, 1927, Paine; soil, Colorado, 1930, LeClerg; soil, Grobnik, Krk Island in Adriatic Sea, 1929, Pišpek.

MATERIAL EXAMINED: Brazil nuts bought in eastern U. S. A. (all nuts presumably from S. America), 1919 (7 races) *Blakeslee* (Acc. nos. 360, 361, 362, 363, 364, 365, 366).

Cunninghamella Blakesleeana was described by Lendner (16) in 1927 with no data given concerning the substrate or locality from which it was collected beyond a brief note to the effect that the material had been forwarded to him by Blakeslee. Previously Blakeslee, Cartledge & Welch (7) had investigated and discussed the sexual condition in an undescribed species which they designated as *Cunninghamella* "A." At this time they pointed out that in many respects *Cunninghamella* "A" was intermediate between *C. echinulata* and *C. Bertholletiae*, the appearance of the colony recalling *C. echinulata*, but the aspect of the spores and conidiophores more closely approaching *C. Bertholletiae*. Lendner's description of *C. Blakesleeana* emphasized this situation, and at the start of this study it was assumed that *Cunninghamella* "A" and *C. Blakesleeana* were synonymous.

Recently in a personal communication Professor Blakeslee has informed the author that his material of *Cunninghamella* "A" did indeed constitute the type material of *C. Blakesleeana.*

The cultures studied here which were obtained from the Blakeslee collection agree well with Lendner's description except that the conidia of these isolates reach somewhat larger dimensions than those given by Lendner. It is not unusual to encounter outsize conidia up to 35 μ long. Furthermore, in this material certain outgrowths of rhizoids or sterile mycelium upon the aerial hyphae were very apparent, a feature not mentioned in Lendner's description. The presence of these rhizoidal tufts upon the mycelium in the aerial portions of the colony imparts a very characteristic appearance during the early stages of growth, and in conjunction with the pure white color of the colonies provides an easy macroscopic method of distinguishing this species from *C. elegans* and *C. Bertholletiae.*

The frequently irregular or pseudoverticillate branching of the conidiophores and the more heavily echinulate conidia are further differences between *C. Blakesleeana* and the above-mentioned species. Conidial measurements and shapes of these forms tend to overlap and do not seem reliable criteria for their separation. The data presented by Blakeslee, Cartledge & Welch based upon a study of the sexual conditions in this form and in *C. elegans* and *C. Bertholletiae* indicate that it is physiologically distinct from the latter species.

The zygospores are described by Lendner and are said to differ from those of *C. echinulata* and *C. elegans* in the shape of the segments of the epispore which are somewhat depressed or hollowed in the center, rather than flat as in *C. elegans* or tuberculate as in *C. echinulata.*

Cunninghamella verticillata Paine (22), described three months after *C. Blakesleeana*, corresponds so closely with it that it must be incorporated here. The description of *C. echinata* Pišpek fits *C. Blakesleeana* so well that it seems probable the two species are synonymous although Pišpek's description leaves much to be desired. Since *C. echinata* has never been reported subsequently and since there are no significant differences between the description of it and of *C. Blakesleeana*, Pišpek's species is here reduced to synonymy.

In common with *C. Bertholletiae*, this species occurs predominantly upon substrates with high oil or fat content, as is indicated by its repeated isolation from Brazil nuts. A detailed study of a large series of isolates from this and other substrates may reveal strains intermediate in character between this species and *C. Bertholletiae* and *C. elegans* which will necessitate the combining of this complex into one inclusive species. On the basis of our present knowledge it appears desirable to maintain them as distinct entities.

4. **Cunninghamella Bertholletiae** Stadel, Dissertation, Kiel, pp. 1–35. 1911.

PLATE II, E–G

"Colonies white, yellow to light olive, dense with interwoven mycelium, up to 2 cm. high. Conidiophores verticillately branched, the laterals sometimes showing secondary

branching. Conidiophores 9–19.2 μ thick, with heads up to 70 μ in diam., average 40–50 μ; swellings 5 x 4 μ up to 30–55 μ in diam. Conidia oval or having the form of a cucumber seed, echinulate, 16–25 x 10–12 μ, or spherical, more nearly smooth 8–9 μ in diam. Sterigmata up to 2.75 x 0.8 μ. Chlamydospores present, up to 30–40 μ in diam. Oily material usually present in mycelium, conidiophores and conidia. Species showing an affinity for oily substrates." Stadel.

Zygospores have been reported by Blakeslee, Cartledge & Welch (7) but never described.

On M.D.A. agar:

Colonies up to 2.5 cm. high, spreading rapidly, "Gull Grey," somewhat compacted, sometimes growing at 40° C.; *sterile mycelium* much branched with some spherical to ovoid chlamydospores up to 35 μ in diam. containing much oily or granular material; *conidiophores* erect, verticillately branched at some distance below the terminal heads, with as many as five whorls of lateral branches; laterals usually more than 50 μ long; vesicles subglobose to clavate, when young tuberculate or verrucose, in age becoming smooth, up to 65 μ in diam., at times filled with large oil globules; *conidia* characteristically lacrymoid, sometimes subspherical or ellipsoid, with prominent apiculus, up to 16 x 12 μ, average 9 x 7 μ, hyaline, echinulate with very short spines or asperulate; *zygospores* not seen.

TYPE LOCALITY: Nuts of *Bertholletia excelsa*, Brazil, 1911. Stadel.

DISTRIBUTION: Brazil nuts, Massachusetts, 1919, Burger; New York and localities in eastern U.S.A., 81 races (all nuts presumably collected in S. America) 1921, Blakeslee, Cartledge & Welch; soil, Moscow, Idaho, 1937, Alcorn & Yeager.

MATERIAL EXAMINED: Brazil nuts, locality unknown via American Type Cult. Coll., 1943, (Acc. nos. 95, 96, 353); via Blakeslee coll., 1943, (Acc. nos. 367, 368, 369, 370, 371, 372, 373).

Lendner (16) calls attention to the fact that this species is very close to *C. elegans*, and considers them synonymous. Zycha (38) follows this treatment, whereas Naumov (20) and Alcorn & Yeager (1) retain *C. Bertholletiae* as a specific entity. In this connection it should be recalled that Blakeslee, Cartledge & Welch (7) in their extensive work on the sexuality of *Cunninghamella* apparently experienced no difficulty in separating the two species and obtained no evidence that they were conspecific. Furthermore with the exception of Alcorn & Yeager's record, *C. Bertholletiae* has been reported only from decaying Brazil nuts while *C. elegans* is predominantly a soil inhabiting form. In the case of the race of *C. Bertholletiae* collected from Idaho soil by Alcorn & Yeager, their emended description does not coincide at all well with the original description. Furthermore their translation of Stadel's description contains certain inaccuracies which may arise from the fact that they cite as the source of this diagnosis not Stadel's own work, but only a review of it prepared by Leeke (13). Therefore the only valid evidence that the Idaho form is actually *C. Bertholletiae* is the fact that it was reputed to form zygospores when contrasted with a

minus race of this species in Blakeslee's laboratory. Under the circumstances this record must be viewed with some scepticism.

When cultured upon M.D.A. agar there are certain minor differences between the two species. *C. Bertholletiae* usually develops chlamydospores, whereas these structures are lacking in *C. elegans*. In all the material examined here the mycelium of *C. Bertholletiae* was consistently filled with granular materials or oil globules, a condition not seen in *C. elegans*. The conidia of the former are more consistently apiculate than are those of the latter, and the lateral branches of the conidiophores of *C. Bertholletiae* are on the average somewhat shorter and stouter. It must be emphasized, however, that these are not reliable criteria for the separation of the two species and are useful only in connection with a large series of isolates.

Perhaps the most significant difference between the two species is the ability of certain strains of *C. Bertholletiae* to grow at 40° C. No strains of *C. elegans* were encountered which could endure this temperature. Four of the ten cultures of *C. Bertholletiae* studied here exhibited this peculiarity. This variability between morphologically identical strains cannot be satisfactorily accounted for at the present time. However, all the cultures studied had been grown upon artificial media for a number of years before they were tested, and it is possible that during this time certain of them lost the ability to grow at higher temperature levels. While this speculation is in no sense conclusive, the temperature growth relationships of these species may prove very significant in effecting a satisfactory separation, and should be investigated in greater detail with freshly collected cultures. The only other species of *Cunninghamella* consistently able to grow at temperatures of 40° C. or higher is *C. echinulata*. In the key presented above *C. Bertholletiae* has been so placed that it may be identified in either temperature category.

In the light of the results of Blakeslee, Cartledge & Welch, and the failure in the present study to obtain zygote formation between oppositely sexed races of these two species contrasted under favorable conditions of temperature and nutrition, it seems reasonable to conclude that they are at least physiologically distinct. Consequently *C. Bertholletiae* is retained until more cogent proof of its conspecificity with *C. elegans* is presented.

5. **Cunninghamella elegans** Lendner, Bull. Herb. Boissier (II) **7:** 250–251. 1907; Les Mucorinées de la Suisse. Berne, 1908.

PLATE II, H

"Colonies white to light ashy, mycelium differentiated into two regions, the submerged region very compact, in age becoming pseudoparenchymatous and cartilaginous, the aerial portion cottony up to 2 cm. high. The conidiophores erect, branching dichotomously several times, aseptate, verticillately branched at a distance below the terminal head. Verticillate branches variable in number, terminated in heads. Terminal heads up to 60 μ in diam., lateral heads 18–20 μ in diam. Conidia of the terminal head ovoid, apiculate at point of insertion, 16 x 12–14 μ up to 14 x 22 μ, armed with very short spines. The lateral conidia smaller and more nearly spherical, 8–10 μ in diam. The conidia impart a pale ashy blue color to the colony. After dissemination of the

conidia the surface of the heads is echinulate with short tubercles, very evenly distributed, marking the points of insertion of the conidia." Lendner (1908).

Zygospores reported by Blakeslee, Cartledge & Welch (7) but never described.

On M.D.A. agar:

Colonies up to 3.5 cm. high, spreading rapidly, "Gull Grey," not growing at 40° C., in age becoming compacted. *Sterile mycelium* much branched, up to 20 μ in diam., aseptate when young, gradually becoming septate in the submerged portions, frequently forming oidia and swellings, true chlamydospores not observed. *Conidiophores* erect, verticillately branched at some distance below the terminal head; lateral branches arranged in a number of successive whorls about the primary conidiophore, laterals usually more than 50 μ long and comparatively slender. Terminal vesicles subglobose to broad clavate, up to 60 μ in diam., lateral vesicles pyriform, subglobose or clavate, up to 40 μ in diam.; vesicles for the most part very closely verrucose or tuberculate, sometimes smooth. *Conidia* hyaline, predominantly ovoid to ellipsoid, occasionally lacrymoid, up to 14–16 μ long x 10–12 μ broad, echinulate with very short spines, asperulate, or smooth. *Zygospores* not seen.

TYPE LOCALITY: Garden soil, near Geneva and Vuache, Switzerland, Lendner.

DISTRIBUTION: Soil, Cold Spring Harbor, N. Y., (42 races) 1921, Blakeslee, Cartledge & Welch; Germany, 1929, Janke; South Slavia 1929, Pišpek; Evanston, Illinois, 1929, Swift; France, 1930, Ling-Young; Bastrop Co., Texas, 1932, Morrow; Germany, 1935, Zycha; Ann Arbor, Michigan, 1914, 1917, Povah; Moscow, Idaho, 1937, Alcorn & Yeager; Canada, 1938, Bisby; North Carolina (several localities), 1940, Christenberry.

MATERIAL EXAMINED: Peas, Wellington, Ont., Arnprior, Ont., Brittania Bay, Ont., Canada, 1943, *Groves* (Acc. nos. 141, 312, 316); flaxseed, Richmond, Ont., Saskatoon, Sask., Winkler, Man., Canada, 1943, *Groves* (Acc. nos. 209, 224, 296); locality and substrate unknown, via American Type Cult. Coll. and *S. A. Waksman*, 1943 (Acc. nos. 349, 355, 357); locality and substrate unknown via Blakeslee Coll., 1943 (Acc. nos. 380, 381, 382, 383, 384, 385); parsley seed, New Haven, Conn., and Gilroy, Calif., 1942, *Groves* (Acc. nos. 388, 390); lettuce seed, Philadelphia, Pa., and San Francisco, Calif., 1942, *Groves* (Acc. nos. 389, 398); spinach seed, Toledo, Ohio, and Milford, Conn., 1942, *Groves* (Acc. nos. 395, 396); pepper seed, Toledo, Ohio, 1942, *Groves* (Acc. no. 391); pumpkin seed, Milford, Conn., 1942, *Groves* (Acc. no. 392); celery seed, Detroit, Mich., 1942, *Groves* (Acc. no. 393); muskmelon seed, New Haven, Conn., 1942, *Groves* (Acc. no. 394); carrot seed, Minneapolis, Minn., 1942, *Groves* (Acc. no. 397).

This species is common in seeds and soil throughout the temperate regions of the world. As yet no tropical records are available. The small, asperulate or shortly echinulate conidia and consistently verticillate branching of the conidiophores, with long, slender, lateral branches, make *C. elegans* easily distinguishable from all other described species except *C. Bertholletiae*. The distinguishing features of these two species have been

previously outlined. Lendner has described the peculiar vesicular swellings formed in liquid media by this species. The same phenomenon is exhibited by all isolates of *Cunninghamella* under unfavorable conditions. It must be recognized that these structures are not true chlamydospores, which in the material examined by the author occur only in *C. echinulata* and *C. Bertholletiae*. These chlamydospores are thick-walled resistant bodies, intercalary in the mycelium, while the vesicles merely represent thin-walled swollen portions of the submerged mycelium.

DOUBTFUL SPECIES

Cunninghamella albida (Saccardo) Matruchot, Ann. Mycol. **1:** 56. 1903.
Oedocephalum albidum Saccardo, Michelia **2:** 288. 1881.
Haplotrichium albidum Saccardo, Michelia **2:** 288. 1881 and Fungi Italici: fig. 805. 1881.

"Sterile mycelium repent, much branched, aseptate, hyaline. Conidiophores erect or decumbent similar to the sterile mycelium, aseptate and hyaline, simple or occasionally giving off lateral conidiophores terminated by finely muriculate vesicles. Conidia arising from the tubercles of the vesicles globose to globose elliptical (not concatenate) 2–10 μ in diam., hyaline white to pale yellow." Saccardo.

In dead and decaying roots of *Citrus Limonii* Salo, Italy, 1874.

As far as is known this species has never been collected since the original report. There seems little doubt that Saccardo was dealing with a species of *Cunninghamella* but the figure and fragmentary description given offer little possibility of future identification. Zycha and Naumov have interpreted *C. albida* as having unbranched conidiophores and use this character to separate it from other species of *Cunninghamella*. This interpretation arises from a liberal translation of the original Latin description. On the other hand, Saccardo's illustration shows a form with verticillate and dichotomously branched conidiophores, as well as several young unbranched conidiophores. Were it not for the smooth-walled conidia the species would conform well with *C. Blakesleeana*. However, in the absence of further information concerning the essential dimensions of this species, any speculation in regard to its synonymy appears unwarranted. It is therefore retained as a provisional species but not included in the key.

Actinocephalum japonicum Saito, Bot. Mag. Tokyo **19:** 1. 1904.
Saitomyces japonicus (Saito) Ricker, Journ. Mycol. **12:** 61. 1906.

"Turf grayish, mycelium irregularly branched covering the substrate; sporangiferous hyphae erect, lacking basal rhizoids, in general verticillately branched, branches terminally inflated, vesicles 25–55 μ in diam.; conidia globose or sometimes oval, 20 by 18–21 μ, inserted individually on sterigmata, hyaline, echinulate, zygospores and chlamydospores unknown." Saito.

TYPE LOCALITY: Air borne, Musashi Province, Japan.

This species placed in *Cunninghamella* by Fitzpatrick (11) and subsequently by Zycha (38) and Naumov (20), appears identical with *C. Bainieri*. Zycha and Naumov consider it synonymous with *C. elegans* Lendner, but the short verticillate lateral branches shown in Saito's illustrations and

the large finely echinulate subspherical conidia are not consistent with the concept of *C. elegans*. In the absence of the original material it will probably never be possible to determine its specific affinity.

Cunninghamella dalmatica Pišpek, Acta Bot. Inst. Univ. Zagreb. **4:** 100. 1929.

"Colonies brownish white, 1 cm. high, conidiophores mostly verticillately branched immediately below the apex, terminal heads 28–52.5–56 μ in diam., lightly verrucose; lateral heads 14–24.5 μ diam.; conidia globose 7–8 μ diam. to ovoid 7–14 μ long by 7–10.5 μ wide." Pišpek.

TYPE LOCALITY: Cultivated soil near Jesenice, Dalmatia.

MATERIAL EXAMINED: Locality, date, and substrate unknown, C.B.S. via Blakeslee (Acc. no. 386).

The incomplete description given by Pišpek will not allow this species to be positively identified. The culture received under this designation from Professor Blakeslee's collection is believed to represent a subculture of Pišpek's type. Upon examination it proved identical with *C. Bainieri*. This cannot be accepted as conclusive evidence that these two forms are synonymous because of the possibility of contamination during transfer of the cultures. On this basis, and because of the incomplete diagnosis furnished by Pišpek, there is no justification for maintaining *C. dalmatica* as a valid species.

Cunninghamella ramosa Pišpek, Acta Bot. Inst. Univ. Zagreb. **4:** 102. 1929.

"Colonies yellow-brown, 2 cm. high, externally resembling certain Absideae. Conidiophores in the middle of the culture for the most part simply branched, frequently inflated at the base, those on the outer periphery of the culture abundantly sympodially or irregularly branched; terminal heads for the most part verrucose 42–59–77 μ in diam.; lateral heads 14–38 μ wide; spores mostly globose, very large, yellowish, granular within, not echinulate, 10.5–24.5–35 μ in diam. or globose and pyramidal, 10.5–14 μ long by 7–9–10.5 μ wide; chlamydospores not seen, zygospores unknown." Pišpek.

TYPE LOCALITY: Rich pasture soil near Kraljevo (Serbia occid.).

On the basis of Pišpek's description this species appears closely related to *C. Bainieri*. The only significant differences are the irregular branching of *C. ramosa* and its predominantly smooth-walled conidia. However, Plate I, M shows an irregularly branched conidiophore of *C. Bainieri* and smooth-walled giant conidia are not infrequently found in this species. The large dimensions of the conidia of Pišpek's isolate certainly indicate a close connection with *C. Bainieri*. This species has never been reported subsequently, and until more information can be accumulated its validity must be questioned.

Cunninghamella polymorpha Pišpek, Acta Bot. Inst. Univ. Zagreb. **4:** 103. 1929.

"Colonies brownish white, dense, 2 cm. high, conidiophores very diversely branched; terminal heads verrucose, 32–49–55 μ in diam.; lateral heads 10.5–17.5–25 μ in diam.; spores globose 7–14–(17.5) μ in diam., or ovoid to ellipsoidal 7–10.5–(14) μ wide by 7–10–(17) μ long, hyaline or yellowish; chlamydospores not seen, zygospores unknown." Pišpek.

TYPE LOCALITY: Soil between rocks on Mt. Puvarov, elevation 1300 metres, Croatia.

MATERIAL EXAMINED: Locality, date, and substrate unknown. C.B.S. via Blakeslee (Acc. no. 387).

The isolate of this species received from Professor Blakeslee's collection was identical with isolates of *C. Bainieri.* The description furnished by Pišpek indicates that the measurements of his type isolate overlap those of *C. dalmatica,* and he presents no significant data which will permit the separation of these two species. On the basis of his description positive identification of *C. polymorpha* is impossible.

EXCLUDED SPECIES

Cunninghamella microspora (Riv.) Matruchot, Ann. Mycol. **1:** 56. 1903.

Gonatobotrys microspora Rivolta, Dei Parassiti Vegetali, p. 490. Torino, 1873.
Prachtflorella microspora (Riv.) Matruchot, Ann. Mycol. **1:** 56. 1903.

This species, placed in *Cunninghamella* by Matruchot, has been incorporated in the genus by all subsequent authors, although as far as can be determined it has been reported only by Rivolta in 1873 and by Berlese in 1889. Rivolta's description consists of the single line "La Gonatob. microspora. — Ha le spore piccolissime.", and the single figure given is too fragmentary to give any real concept of the species. Knowledge of the form is therefore confined to the descriptions and figures presented by Berlese from material encountered on dead and decaying bark of *Morus alba* in Northern Italy. A perusal of this description shows this species to be quite different from any of the forms discussed above. The restricted nature of the colony, the extremely small dimensions of the mycelium (2–3 μ in diam.), and particularly the presence of unbranched conidiophores with intercalary spore-bearing nodes are characters not associated with the original concept of *Cunninghamella* as outlined by Thaxter and Matruchot. Furthermore, the elongate, basally apiculate, smooth conidia do not correspond well with the usual conidial type in *Cunninghamella.* Matruchot's comments on the relationships of *C. microspora* and his proposal of the alternate name *Prachtflorella microspora* indicate that his disposition of it was provisional, and subsequent studies have not yet confirmed his opinion. In the absence of any knowledge of the sexual stage of this species it seems advisable to exclude it from *Cunninghamella.*

Cunninghamella mandshurica Saito & Naganishi, Bot. Mag. Tokyo **39:** 285. 1913.

This species has been shown to belong in *Choanephora* by Fitzpatrick (11). The longitudinally striate conidia exclude it from *Cunninghamella,* although the type of branching is in some respects intermediate between the two genera. Zycha (38) considers the species synonymous with *Choanephora cucurbitarum.*

ACKNOWLEDGMENTS

The author wishes to extend special thanks to Dr. J. Walton Groves of the Canadian Department of Agriculture for the contribution of a large series of cultures which made possible this study. Acknowledgment is also made to Dr. D. H. Linder and Dr. W. L. White of the Farlow Herbarium, Harvard University, and Dr. S. A. Waksman who have contributed cultures and made many helpful suggestions. The curators of the American Type Culture Collection have most generously cooperated by making available all cultures of *Cunninghamella* in their collection. Dr. Kenneth Raper has extended valuable aid by donating many cultures from the Blakeslee Collection. Finally the author wishes to acknowledge the aid of Miss Shirley Weinstein, who assisted in the cultural studies of this material.

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BIBLIOGRAPHY

1. **Alcorn, G. D., & C. C. Yeager.** A monograph of the genus *Cunninghamella*, with additional descriptions of several common species. Mycologia **30:** 653–658. 1938.
2. **Bainier, G., & A. Sartory.** Etudes morphologique et biologique du *Muratella elegans* n. sp. Bull. Soc. Mycol. France **29:** 129–136. 1913.
3. **Berlese, A. N.** Fungi Moricolae. Padova, 1889.
4. **Bisby, G. R.** Who is the author? Trans. British Mycol. Soc. **25:** 434–435. 1942.
5. **Blakeslee, A. F.** Sexual reproduction in the Mucorineae. Proc. Amer. Acad. Arts and Sci. **40:** 205–319. 1904.
6. ————. Two conidia-bearing fungi. *Cunninghamella* and *Thamnocephalis*, n. gen. Bot. Gaz. **40:** 161–170. 1905.
7. **Blakeslee, A. F., J. L. Cartledge & D. S. Welch.** Sexual dimorphism in *Cunninghamella*. Bot. Gaz. **72:** 185–219. 1921.
8. **Briquet, J.** International Rules of Botanical Nomenclature. Jena, 1935.
9. **Burger, O. F.** Sexuality in *Cunninghamella*. Bot. Gaz. **68:** 134–146. 1919.
10. **Christenberry, G. A.** A taxonomic study of the Mucorales in the southeastern United States. Journ. Elisha Mitchell Sci. Soc. **56:** 333–366. 1940.
11. **Fitzpatrick, H. M.** The Lower Fungi; Phycomycetes. New York, 1930.
12. **LeClerg, E. L.** Cultural studies of some soil fungi. Mycologia **22:** 186–210. 1930.
13. **Leeke, N.** Review of, Stadel, O. Über einen Neuen Pilz *Cunninghamella Bertholletiae*. Dissert. Kiel, 1911. Mycol. Centralbl. **1:** 218–219. 1912.
14. **Lendner, A.** Sur quelques Mucorinées. Bull. Herb. Boissier. ser. II, **7:** 250–251. 1907.
15. ————. Les Mucorinées de la Suisse. Berne, 1908.
16. ————. Une nouvelle espèce de Mucorinée, le *Cunninghamella Blakesleeana* Lendner. Bull. Soc. Bot. Geneva **19:** 234–238. 1927.
17. **Ling-Young, M.** Étude biologique des phénomènes de la sexualité chez les Mucorinées. Rev. Gen. Bot. **42:** 722–752. 1930.
18. **Matruchot, L.** Une Mucorinée purement conidienne, *Cunninghamella africana*. Ann. Mycol. **1:** 45–60. 1903.
19. **Morrow, M. B.** The soil flora of a pine forest. Mycologia **24:** 398–402. 1932.
20. **Naumov, N. A.** Clés des Mucorinées. Paris, 1939.

21. **Ou, S. K.** Phycomycetes of China I. Sinensia **2:** 427–449. 1941.

22. **Paine, F. S.** Studies of the fungous flora of virgin soils. Mycologia **19:** 248–267. 1927.

23. **Pišpek, P. A.** Edafske mukorinje Jugoslavije. Acta Bot. Inst. Bot. Univ. Zagreb. **4:** 77–112. 1929.

24. **Povah, A. H. W.** *Helicostylum* and *Cunninghamella:* two genera of the Mucorales new to the state. Ann. Rept. Mich. Acad. Sci. **17:** 152–155. 1915.

25. **Ricker, P. L.** Second supplement to new genera of fungi published since the year 1900, with citation and original descriptions. Journ. Mycol. **12:** 60–67. 1906.

26. **Ridgway, R.** Color Standards and Nomenclature. Wash., D. C. 1912.

27. **Rivolta, S.** Dei Parassiti Vegetali. Torino, 1873.

28. **Saccardo, P. A.** Fungi veneti novi vel critici v. mycologiae venetae addendi. Series XII. Michelia **2:** 241–301. 1881.

29. ————. Fungi Italici Autographice Delineati. fig. 805. Patavii, 1877–1886.

30. ————. Syll. Fung. **17:** 508. 1905.

31. **Saito, K.** *Actinocephalum japonicum* nov. gen. et nov. spec. Bot. Mag. Tokyo **19:** 36–38. 1905.

32. **Saito, K. & H. Naganishi.** Eine Neue Art von *Cunninghamella.* Bot. Mag. Tokyo **29:** 285–286. 1915.

33. **Stadel, O.** Über einen neuen Pilz, *Cunninghamella Bertholletiae.* Dissert. Kiel. 1–35. 1911.

34. **Swift, M. E.** Contributions to a mycological flora of local soils. Mycologia **21:** 204–221. 1929.

35. **Thaxter, R.** On certain new or peculiar North American Hyphomycetes. I. *Oedocephalum, Rhopalomyces* and *Sigmoideomyces* n. g. Bot. Gaz. **16:** 14–26. 1891.

36. ————. A New England Choanephora. Rhodora **5:** 97–102. 1903.

37. **Torrey, G. S.** Les Conidies de *Cunninghamella echinulata* Thaxter. Bull. Soc. Mycol. France **37:** 93–99. 1921.

38. **Zycha, H.** Kryptogamenflora der Mark Brandenburg, Pilze II, Mucorineae: 1–264. Leipzig, 1935.

EXPLANATION OF PLATE I.

All figures drawn with the aid of a camera lucida at a magnification of x1300 and reduced in printing to an approximate magnification of x325.

A–F. *Cunninghamella echinulata.* Types of conidiophores and conidia produced on M.D.A. agar.

G. *Cunninghamella echinulata.* Conidiophore and conidia produced on liquid medium, showing attenuated lateral branches and long echinulations on conidia.

H–I. *Cunninghamella echinulata.* Vesicles and chlamydospores formed on submerged mycelium.

J–M. *Cunninghamella Bainieri.* Types of conidiophores and conidia.

N. *Cunninghamella Bainieri.* Conidiophore showing arrangement of giant conidia on specialized lateral branch.

O. *Cunninghamella Bainieri.* Types of conidia.

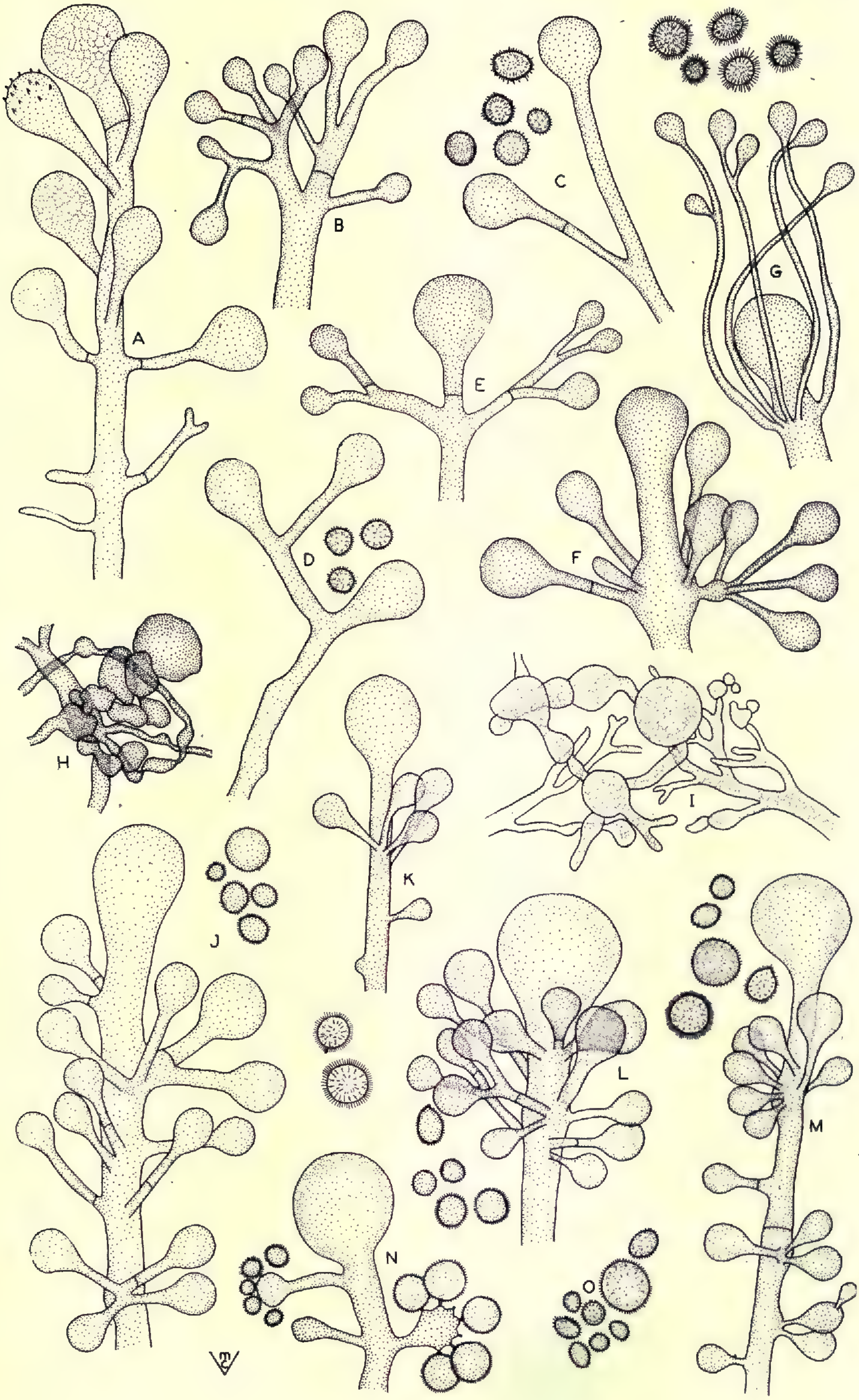

PLATE I

EXPLANATION OF PLATE II.

All figures drawn with the aid of a camera lucida at a magnification of x1300 and reduced in printing to an approximate magnification of x325.

A–D. *Cunninghamella Blakesleeana*. Types of conidiophores and conidia.

E–G. *Cunninghamella Bertholletiae*. Types of conidiophores and conidia.

H. *Cunninghamella elegans*. Conidiophore and conidia.

PLATE II

2(3):345–383 FARLOWIA JANUARY, 1946

A COMPARATIVE STUDY OF TORULOPSIS PULCHERRIMA AND TAPHRINA DEFORMANS IN CULTURE [1]

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INTRODUCTION

The concept of a morphologic or phylogenetic relationship existing between the yeasts and the fungi comprising the order Taphrinales (or Exoascales) is not of recent origin. Reess (1870), De Bary (1884), and Hansen (1904) all expressed such an opinion, based upon macroscopic and microscopic resemblances in culture between the two groups of fungi. At present, two widely used schemes of mycological classification, that of Gäumann and Dodge (1928) and that of Bessey (1935, 1942), differ radically in regard to the relative positions of the Taphrinales and the yeasts. From a phylogenetic point of view, Gäumann and Dodge place the two groups in the primitively simple Hemiascomycetes, but separate the yeasts from the Taphrinales by relegating the former to the order Endomycetales. On the other hand, Bessey regards the yeasts and the Taphrinales as being widely separated, the latter representing an offshoot of the Pezizales (which he assumes to be primitive), while the yeasts are regarded as "the ultimate degree of simplification in the Class Ascomyceteae" and are therefore placed at the end of this group. In 1937 Guilliermond concluded that ". . . les Exoascées que la plupart des mycologues modernes s'accordaient à séparer radialement des levures et à rattacher aux Ascomycètes supérieurs . . . nous apparaissent, au contraire, beaucoup plus proches des levures qu'on ne le pensait et l'on en revint ainsi aux anciennes conceptions de Reess, de Bary et Hansen."

These concepts were based on similarities evident in culture, but it should be emphasized that only one phase in the life cycle of *Taphrina* — the saprophytic, budding stage — has been found to be readily capable of development on artificial media. The parasitic, mycelial stage of this genus, involving sexuality, has resisted all attempts at culture, exclusive of scattered reports in the literature to be referred to later in more detail.

In brief, the life cycle of *Taphrina deformans* (Berk.) Tul., the causal agent of peach leaf curl and the species investigated in this study, is as follows: Asci are formed in the spring and summer on the surfaces of infected leaves, and each normally produces eight haploid ascospores which are discharged in a group. The ascospores fall to various parts of the host plant and initiate a yeast-like budding or sprout conidial stage, in which

[1] Portion of a thesis submitted to the Graduate Division, University of California in partial satisfaction for the degree of Doctor of Philosophy, October, 1943. The valuable advice and criticisms offered during the course of the investigation and in the preparation of the manuscript by Prof. J. T. Barrett, Dr. H. N. Hansen, Dr. E. M. Mrak, and Prof. M. W. Gardner are gratefully acknowledged.

form the organism overwinters. In the following spring when the leaf buds are expanding, infection occurs through penetration by an infection hypha produced by germination of the sprout conidium. It is believed (Eftimiu 1927, Fitzpatrick 1934, Martin 1940) that the occurrence of nuclear division without cross-wall formation in this germinating cell is responsible for the origin of the binucleate or dicaryon condition which is evident in the cells of the intercellular mycelium subsequently developing throughout the leaf tissue. From this mycelium is formed a subcuticular layer of rather thick-walled binucleate cells, the ascogenous cells. Karyogamy occurs in these, followed by the extrusion of the cell wall to form the ascus, which in its development ruptures the cuticle. The diploid fusion nucleus divides mitotically, one of the daughter nuclei passing into the ascus, which is then cut off from the ascogenous cell by a cross wall. Meiotic and mitotic nuclear divisions then occur, resulting in the formation of eight haploid ascospores, and the cycle is completed. In investigations of other species of *Taphrina* by Wieben (1927) the origin of the dicaryon was reported to occur through the copulation of physiologically differentiated ascospores or their derivatives, but in *T. deformans* only rare instances of copulation have been noted (Mix 1929), and it is generally believed that this species is homothallic.

As a group, the yeasts are readily culturable and may be maintained for long periods of time on various types of artificial media, both natural and synthetic. The majority of the yeasts are saprophytic organisms, but parasitic forms exist, both on plants and animals. Yeasts fall into two main groups — the sporogenous or sporulating and the asporogenous or non-sporulating forms. The sporulating yeasts pass through complete life cycles in culture, and although the types of sexuality involved are greatly diversified, the formation of ascospores within asci at some stage in development is a constant occurrence in all those organisms investigated. Those yeasts which have never been known to produce spores in culture are known as the imperfect yeasts and have been regarded by some as perfect yeasts which have lost their sporulating ability. They are placed among the Fungi Imperfecti, and, as would be expected, no attempt to relate them one to another in a natural system is made, but they are merely classified for convenience in identification. Their development in culture lacks any type of sexuality or alternation of haploid and diploid generations and consists merely of a predominantly budding type of vegetative reproduction, which often exhibits a pseudomycelial tendency. The genus *Torulopsis* is classified with the imperfect yeasts in the family Torulopsidaceae and the sub-family Torulopsidoideae, the latter being characterized by the absence of pseudomycelium, or, if present, by a very primitive type (Lodder 1934).

An important contribution to our knowledge of the imperfect yeasts was made by Lodder in 1934. As a result of a detailed study of the physiology and morphology of these organisms (exclusive of the pseudomycelial-forming Mycotoruloideae), she erected a scheme of generic and specific determination which has since been recognized as the standard scheme of

classification for these non-sporulating forms. From the standpoint of the problem of the relationship between the yeasts and the Taphrinales, this work is significant because of the fact that if this key is used, the genus *Taphrina*, as represented by its saprophytic budding stage in culture, will fall into the genus *Torulopsis*. The importance of this can hardly be over-emphasized, for it is possible, therefore, that isolates of *Taphrina* may be identified as belonging to the genus *Torulopsis*. The differences in the natural habitats of these two groups of fungi are not so great as to preclude their being isolated from similar or identical material, for, although the budding stages of the parasitic species of *Taphrina* are quite closely associated with their hosts, the species of *Torulopsis* are quite widespread and have been isolated from a great variety of living and non-living material. In this connection, the investigations of Koch (1934) on the overwintering of parasitic and saprophytic fungi on fruit trees stress the actual difficulty involved in the identification of isolates of *Taphrina deformans*. Koch states, "Among numerous other fungi appearing in isolations from buds and bark of *Prunus persica*, an organism resembling *Taphrina deformans* appeared on five occasions . . . as this organism is somewhat difficult to distinguish from certain 'budding' saprophytic fungi, many of which appear consistently in isolations from the bark of peach trees, it was necessary to prove the identity of the organism by inoculation."

Studies of the general cultural behaviour of species of *Taphrina* have already been referred to, but some recent investigations of *Torulopsis* spp. in culture are worthy of mention at this time. Punkari and Henrici (1933, 1935), through the employment of single cell technique, studied the cultural variation occurring in several generations of *Torulopsis pulcherrima* (Lindner). Saccardo and noted striking dissociation into pigmented and non-pigmented colonial areas. The white variants, although showing a tendency to "breed true," were never completely stable, and the authors concluded that these phenomena could be explained by the occurrence of "mutation-like changes" which, in a few cases, appeared to be reversible. Three years later, Porchet (1938), although apparently unaware of Punkari and Henrici's contributions, also reported the occurrence of dissociation in *T. pulcherrima*. Her results, based upon mass transfer technique, indicated that the formation of the pigmented and non-pigmented types may be a reversible phenomenon. In 1936 there appeared a paper by Todd and Herrmann dealing with the life cycle of a yeast which is known as the causal agent of yeast meningitis. This organism had been known as *Torula histolytica* Stoddard and Cutler until Lodder (1934), considering the generic name *Torula* Turpin to be invalid, designated it as *Torulopsis neoformans* (Sanfelice) Lodder. Todd and Herrmann, however, on the basis of priority, adopted the name *Cryptococcus hominis* Vuillemin and described the occurrence of heterogamous copulation and the formation of single-spored, thick-walled asci in this organism. This constituted the first report of sporulation in the genus *Torulopsis*. Because of the transformation of the zygote into the ascus, and the formation of only one ascospore per ascus,

Todd and Herrmann designated the perfect stage of *C. hominis* as *Debaryomyces hominis* (Vuillemin) Todd and Herrmann. A complete life cycle was then formulated for this species, but it should be pointed out that it was based on isolated observations of various types of morphological structures, the actual sequence of events in the developmental life cycle of individual cells not having been observed. Confirmation of Todd and Herrmann's observations on the formation of single spores in this yeast was reported by Giordano (1938–39) and Henrici (1941), the latter also citing a paper by Redaelli, Ciferri, and Giordano (1937) in which sporulation was described.

In 1938 Windisch described for the first time heterogamous copulation and subsequent ascospore formation in *Torulopsis pulcherrima*, apparently occurring in response to the effect of a *Penicillium* contaminant in the cultures. In this organism, four spores were produced per ascus.

Two years later Windisch (1940) in a lengthy paper supplemented by drawings and photomicrographs described in detail the life cycle of *T. pulcherrima* (in pure culture) with particular emphasis laid upon the method of sporulation. In addition, observations were made upon another imperfect yeast, *Candida tropicalis* (Castellani) Berkhout [2] and a discussion of the relationship of these fungi to each other and to the Taphrinales was included. Through actual observation of the developmental sequence of individual cells in hanging drop cultures, Windisch was able to formulate a life cycle for *T. pulcherrima* which, in brief, is as follows: Large thick-walled cells containing large oil droplets (typical "pulcherrima cells") which were interpreted as ascus mother cells (ascogenous cells) occurred in old cultures; these gave rise to bud-like protrusions into which passed a portion of the oil droplet and in which were subsequently formed four ascospores; rupture of the wall of this protrusion (or ascus) liberated the spores, the empty ascus wall remaining attached to the ascus mother cell; copulation occurred between cells derived from germination of the ascospores and resulted in the subsequent formation of large thick-walled "pulcherrima cells." Nuclear staining revealed a binucleate condition in all vegetative cells as well as in the ascus mother cells. These phenomena, which were also similar to those of *Candida tropicalis*, were interpreted by Windisch as being indicative of a definite relationship with the Taphrinales. He therefore proposed that *T. pulcherrima* be incorporated in the genus *Candida* as *C. pulcherrima* and "alle candidoiden Pilze mit gleichartigen Entwicklungsgängen zusammenzufassen in der neuen Familie der Candidaceae, die in der Ordnung der Exoascales einzureihen wäre."

It should be noted that these proposals of Windisch were based upon a comparison of the cultural behaviour of *T. pulcherrima* with previous descriptions in the literature of the culturable as well as the parasitic stages of *Taphrina*, especially those of Wieben on the heterothallic species, *T.*

[2] The genus *Candida* is placed in the family Torulopsidaceae but because of abundant production of pseudomycelium is included in the sub-family Mycotoruloideae, rather than with *Torulopsis* in the Torulopsidoideae (Lodder 1934).

epiphylla Sadeb. and *T. klebahni* Wieben. Windisch made no comparative studies on the behaviour of *Taphrina* spp. in culture.

In the present investigation, a study of the comparative cultural behaviour of one isolate of *T. pulcherrima* and several isolates of *T. deformans* was made in order to obtain additional information which could be used either in substantiation or rejection of the proposals of Windisch in regard to the relationship between *T. pulcherrima* and the genus *Taphrina*. *T. deformans* was chosen for this purpose because its economic importance has attracted the attention of a large number of investigators, whose cumulative efforts have resulted in this species having become the best known representative of the Taphrinales. It is, of course, obvious that a comparative study of any two species based upon observations of only one or a few isolates from each will not give a complete picture of the range of existing differences or resemblances. The present results, therefore, are considered of necessity only preliminary, but it is hoped that they may be used as a basis for future comparative studies of these or similar organisms.

MATERIALS AND METHODS

SOURCES OF CULTURES

The strain of *Torulopsis pulcherrima* used in this investigation was kindly supplied by Dr. E. M. Mrak of the Division of Fruit Products, University of California, and had been isolated by him from the surfaces of ripe Concord grapes obtained in Walnut Creek, California. This particular isolate had been maintained in culture for several years prior to the present investigation.

Isolates of *Taphrina deformans* were secured from infected leaves of peach trees growing on the Berkeley campus and in Piedmont in April and May, 1941, and in the Kirkman Nurseries in Bethany, California, in April, 1942. The peach trees from which isolations were made consisted of ornamental types of unknown variety as well as the commercial varieties, Yunnan and Shalil.

The usual method of obtaining *Taphrina* spp. in culture was employed (Martin 1925, Mix 1935). This consisted of attaching, by means of melted wax, fragments of infected leaves containing actively discharging asci to the underside of a Petri dish cover which was then placed over the lower half containing solidified agar. Ascospores in groups of eight were subsequently discharged upon the agar surface, and when transferred to agar slants, each individual group budded readily, producing a colony which represented a single ascus culture. In obtaining single spore cultures of *T. deformans*, the eight ascospores derived from a single ascus were separated one from another by means of a micromanipulator which is described below.

STOCK MEDIA

The cultures of both *T. deformans* and *T. pulcherrima* were maintained, for the most part, at room temperature (20°–25° C.) on potato dextrose

agar with a pH range from 5.6 to 6.0. In addition, the vegetable agar of Mrak, Phaff, and Douglas (1942) which consists of equal parts of carrots, beets, cucumbers, and potatoes with 2% agar at a pH of ca. 5.7 was employed. Limited use was made of a medium composed of a juice extraction from leaves of susceptible peach varieties, with the addition of 2% dextrose and 2% agar. Liquid media were not used for maintaining stock cultures.

SINGLE CELL TECHNIQUE

All single cell isolations of both organisms were carried out by means of a locally made micromanipulator attached to the stage of a Leitz compound binocular microscope. A single glass needle, the tip of which varied from about 10 to 17 μ in diameter, was clamped in the holder of the micromanipulator in such a position that its tip was between the low power objective and the object in focus, at a magnification of 100x. Three different motions of the needle in two planes were made possible by three screw adjustments. The culture to be used was streaked across a plate of potato dextrose agar and incubated at room temperature. When growth was evident macroscopically, a block of agar, 10 to 15 mm. square and containing on one edge a portion of the margin of the streak, was cut out and transferred to a sterile slide. This was placed under the low power objective of the miscroscope, and the margin of the colony and the tip of the glass needle were brought into focus. By moving the needle, a single cell at the margin was then separated from the colony by being drawn or pushed along the surface of the agar. Plate I, Fig. 1 shows a single cell separated in such a manner from the margin of a colony of *T. deformans*. After the cell had been moved to a distance of 2 to 5 mm. from the colony, its position on the agar block was designated by making an indentation in the agar around the cell by means of the tip of the needle. Four or five isolations were made on each agar block, which was then placed in a sterile moist chamber, and after one to seven days, depending upon the growth rate of the organism, a small colony derived from the single cell was usually evident under the dissecting microscope (Plate I, Fig. 2). Transfers were accomplished by touching the colony with the tip of a sterile needle and transferring the adhering cells to an agar slant. It was found possible, after some practice, to make twenty-five to thirty single cell isolations with the micromanipulator in an hour. The dilution plate method of isolating single spores as described by Hansen and Smith (1932), although possessing the advantage of greater rapidity, was not satisfactory for the fungi studied because of the comparatively small size of the cells which did not permit them to be easily distinguished under the dissecting microscope from numerous particles apparent in the agar. A definite advantage of the micromanipulator method over the dilution plate method is that the use of the compound microscope with its higher magnification made possible the isolation of any individual cell desired, as well as its positive identification as a thin-walled cell, a thick-walled cell, a rod-shaped cell, etc. A similar technique was used to obtain monosporous cultures of *T. deformans* from dis-

charged groups of eight ascospores, only that here the ascospores were separated one from another by drawing them out with the micromanipulator needle in radial directions from the center of the group.

STAINING METHODS

Most of the observations on cellular morphology were made from unstained living material in water mounts. In a few instances, a stain of cotton blue in lactophenol was used (Rawlins 1933), a .025% solution being found the most satisfactory.

For demonstrating the nuclei in the cells of *T. pulcherrima*, Laustsen's modification of the Feulgen technique (Winge 1935) gave fairly satisfactory results, as had previously been noted by Windisch (1940) for the same organism. The method consists of smearing the organism on a clean slide by means of a cover slip, immersing in chloroform for thirty seconds, immersing in cold water for two minutes, hydrolyzing in 1N–HCl at 60° C. for five to fifteen minutes, washing in water, and staining in alcoholic fuchsin for three hours. This method was not found to be satisfactory as a nuclear stain for the cells of *T. deformans*. The iron-alum-haematoxylin schedule of Rawlins (1933) gave only fair results, while the use of Mayer's haem-alum (Chamberlain 1932) was somewhat more satisfactory. This latter method consisted of smearing the organism on a clean slide which had been coated with a thin film of albumin, fixing in formalin-acetic-alcohol No. 2 (Rawlins 1933), washing in water, staining in Mayer's haem-alum overnight, and counterstaining with either erythrosin or eosin for one-half minute.

PHYSIOLOGICAL TESTS

The comparatively few physiological tests undertaken were performed in accordance with the methods described by Lodder (1934) in her monograph on the imperfect yeasts for the determination of fermentative ability, the determination of sugar assimilation by non-fermenting strains, and the determination of nitrogen utilization.

PHOTOGRAPHY

The majority of photomicrographs were taken with a Zeiss Contax camera with a Miflex attachment. In printing, the microfilms were enlarged 2x.

EXPERIMENTAL RESULTS AND THEIR INTERPRETATION

MACROSCOPIC VARIATION IN CULTURE

The general appearance of the growth of *T. deformans* on potato dextrose agar showed a striking resemblance to that of *T. pulcherrima* on the same medium. Colonies of both organisms may be characterized by the phrase "yeast-like growth," which, although not specific, is nevertheless frequently employed as a descriptive term for the budding stages of various unrelated fungi.

After several weeks at room temperature on potato dextrose agar both *T. deformans* and *T. pulcherrima* produced colonies which were smooth, dull (sometimes slightly glistening), dry, slightly convex, and with predominantly entire borders. The most important distinguishing character between the appearance of the two fungi in culture was in the pigment formation. Although both organisms normally develop reddish or pinkish pigment of a non-carotinoid nature (Lodder 1934), that of *T. deformans* is non-diffusible, while that of *T. pulcherrima* readily diffuses into the surrounding medium. In addition to the diffusibility of the pigment, the two organisms were also distinguished by the actual color of the pigments produced. The pinkish color of the normal colonies of *T. deformans* was identified as pale grayish vinaceous by using Ridgway's color standards (1912), but sectors of greater or lesser intensity of color frequently occurred. The normal colonies of *T. pulcherrima* produced varying shades of red, characterized according to Ridgway as vinaceous russet, avellaneous, sorghum brown, and army brown. In the unpublished description of this strain made at the time of isolation, E. M. Mrak had characterized the colony color as "pale pinkish buff" on wort agar, while Mix (1924) had described the appearance of colonies of *T. deformans* on potato dextrose agar as "moist" and "shining" and their color as "pale vinaceous pink."

The occurrence of cultural variation in the form of sectors was very frequent in mass and single cell colonies of these organisms, and in addition to the colors described above, *T. deformans* frequently produced mustard or Naples yellow sectors as well as white or non-pigmented sectors which darkened with age. *T. pulcherrima* likewise produced abundant non-pigmented sectors which darkened with age to colors characterized as Tilleul-buff and vinaceous buff. Thus, the usage of the term "non-pigmented" as descriptive of white colonies or sectors for comparison with red pigmented colonies is not a completely accurate one, for the white areas may darken with age to shades of pale brown or buff. Likewise, the term "red" is used with reservations, for no distinction is made among the previously described varying shades of red developing in old cultures with diffusible pigment.

Although smoothness appeared to be a normal character of the surface of colonies, both young and old cultures of *T. deformans* at times produced roughened areas, some of which were in the form of sectors. These areas, usually of the papillate type, were found to develop sporadically and seemingly bore no relation to the colony color. Rough surfaces, both papillate and crateriform, were also found in cultures of *T. pulcherrima* but were usually confined to non-pigmented cultures which had darkened with age. The papillate type was much more common in this organism than was the crateriform.

These preliminary observations demonstrated the close resemblance between the cultural appearance of *T. deformans* and *T. pulcherrima*, suggesting the possibility of confusion in identification, especially if Lodder's recent generic key for the determination of the non-sporulating yeasts

is used. Differentiation of the genera on the basis of a diffusible pigment is, of course, possible, but because of the production in culture of non-pigmented variants of both organisms, such types may be isolated directly from nature.

ANALYSIS OF SINGLE SPORE CULTURES OF T. DEFORMANS

With a view toward making a more detailed study of the cultural variation of *T. deformans*, single spore cultures were obtained in 1941 from discharged groups of ascospores in the manner previously outlined. From a total of 215 ascospores discharged, 179, or approximately 83%, were recovered, each being used as the starting point of a monosporous culture. Each culture was designated by three symbols: a Roman numeral indicating the location of the host plant, a letter indicating the individual ascus, and an Arabic numeral indicating an individual ascospore discharged from that ascus. As an example, X–A–8 represented a culture derived from one of eight ascospores which had been discharged from a single ascus produced on an infected leaf of a peach tree growing on the Berkeley campus. Thirty-three discharging asci were used in these isolations, and of that number twenty-five discharged a complete set of eight spores, the other eight asci discharging six or seven spores. Eight complete sets of monosporous cultures out of the twenty-five were actually established in culture, while of the remaining seventeen, two to seven ascospores from each ascus were recovered.

The 179 established cultures, kept at room temperature on potato dextrose agar slants, were observed closely after several months' time in order to determine the extent of variation among the monosporous isolates from individual asci. With reference to the findings of Wieben (1927) on the segregation of sexually differentiated ascospores in the asci of the heterothallic *T. epiphylla* and *T. klebahni*, both Mix (1935) and Fitzpatrick (1934) have shown that in *T. deformans* the eight ascospores from one ascus are sexually undifferentiated, although instances of "occasional" and "incomplete" copulation between cells from different monosporous cultures were observed by Mix. This suggests that the fungus may possibly be heterothallic, and it is conceivable, therefore, that segregation of other factors could occur in the division of the diploid nucleus which might be evident macroscopically as a definite ratio of cultural types among the eight monosporous cultures derived from one ascus. No such ratio of variants appeared, however, in any of the series of monosporous cultures investigated, nor was there any evidence for the occurrence of definite ratios of morphological or physiological variants. The fact appears to be well established, therefore, that neither segregation of sex nor of other factors occurs at the initiation of the haploid phase in the life cycle of *T. deformans*.

It is not to be inferred that variation was absent in the 179 monosporous cultures, for it did occur, and quite abundantly, but not in any definite ratio among the eight cultures derived from one ascus. The cultural variation observed was in the form of variously pigmented sectors arising

sporadically, and often more than one type of sector would appear in the same colony (Plate I, Figs. 3, 4).

These cultures were maintained as stock cultures on potato dextrose agar for a period of two years, during which time they were transferred every

TABLE I

CULTURE	DATE OBSERVED	NORMAL COLOR	SECTORS		
		a	b	c	d
XII–P4	1942	x	x		
	1943	x	x		
XIII–P2	1942	x	x		
	1943	x			
XIII–O2	1942	x		x	
	1943	x			
XIII–H1	1942	x	x		
	1943	x	x		x
XIII–S4	1942	x	x		
	1943	x	x		
XIII–I1	1942	x	x	x	
	1943	x	x		
XIII–T1	1942	x	x		x
	1943	x			
XIII–P8	1942	x			x
	1943	x			
XIII–Q1	1942	x	x		
	1943	x	x		
XIII–K3	1942	x	x	x	
	1943	x			
XIII–K1	1942	x	x		
	1943	x	x		x
XIII–G4	1942	x	x		
	1943	x			x
XIII–E3	1942	x	x		x
	1943	x	x		
VI–B1	1942	x	x		
	1943	x			x

Variations in pigmentation apparent in single spore cultures of *T. deformans* in 1942 and in their sub-cultures in 1943. (*a*, pale grayish vinaceous; *b*, modifications in intensity of *a*; *c*, white; *d*, mustard or Naples yellow.)

three or four months by mass inoculations from the colony, irrespective of the sectoring. In 1942 recorded observations on the sectoring apparent in each culture were made. This was repeated in 1943 on sub-cultures of approximately the same age, and Table 1 is a tabulation of fourteen representative cultures with comparative observations for the two years. It will be noted that in three cases, the 1943 culture had the same macroscopic appearance as did the 1942 ancestral colony, while in eleven cases, the

1943 culture showed more, or less, or a different type of, variation than did the ancestral colony. Because of the technique of transfer, these results are of no significance in regard to the constancy of the variant types, but they are regarded as evidence of the abundant production of varied types of sectors in *T. deformans* maintained in culture.

ANALYSIS OF SINGLE CELL CULTURES OF T. PULCHERRIMA

Studies on the transmission [3] of the cultural variations observed in this organism were undertaken by means of the single cell technique already described. The original stock culture, which had been maintained on vegetable agar at ca. 13° C. for several years, exhibited striking dissociation into red and white areas after several weeks at room temperature on potato dextrose agar. From both the pigmented and the non-pigmented areas of this colony, mass transfers were made. The resulting colony from the white sector developed no pigment, while that from the pigmented area again produced a red colony with white sectors (Plate I, Figs. 5, 6). In all subsequent work on variation, which involved nearly 350 individual isolations during a period of 18 months, single cell technique was employed, and the cultures were maintained on potato dextrose agar at room temperature. The extent of this phase of the investigation makes it impossible to indicate clearly all results on one chart, but Figure 1 represents diagrammatically certain portions of the work. In these charts, each numeral represents an individual colony, and each group of numerals enclosed in a bracket indicates all or part of a series of single cell colonies derived from that portion of the parent colony at which the arrow originates. The actual appearance of each colony is indicated by the letters W or R, the former signifying a pure white or non-pigmented colony, and the latter signifying a red or pigmented colony. When W and R are placed together under one numeral, the colony so indicated was pigmented with one or more white sectors.

Figures 1A and 1B are examples of the most characteristic and frequent type of transmission of cultural variants found in *T. pulcherrima*. It will be noted that in Figure 1A, single cells derived from an entirely white colony give rise to pure white colonies. It will be noted in Figure 1B that cells derived from white sectors also give rise to entirely white colonies; in addition, Figure 1B shows that cells taken from the pigmented portions of colonies with white sectors will give rise to pigmented sub-colonies which again produce white sectors. It should be emphasized that these colonial phenomena — the stability of the white variants and the instability of the pigmented areas — were found constantly, without deviation, in 302 distinct single cell isolations, or in nearly 90% of the total number isolated. (Plate I, Figs. 7, 8.) Consequently, the formation of pure

[3] "Transmission" is used here and elsewhere in this paper in the sense of the reappearance of a cultural type in single cell sub-cultures. It is used in order to obviate any confusion which might arise over the use of the word "inheritance" with its connotation of sexuality.

white colonies or of red colonies with white sectors usually could be predicted merely upon the basis of the portion of the parent colony from which the single cell originated. The abundant production of totally white colonies developing on the same medium which supported the growth of pigmented

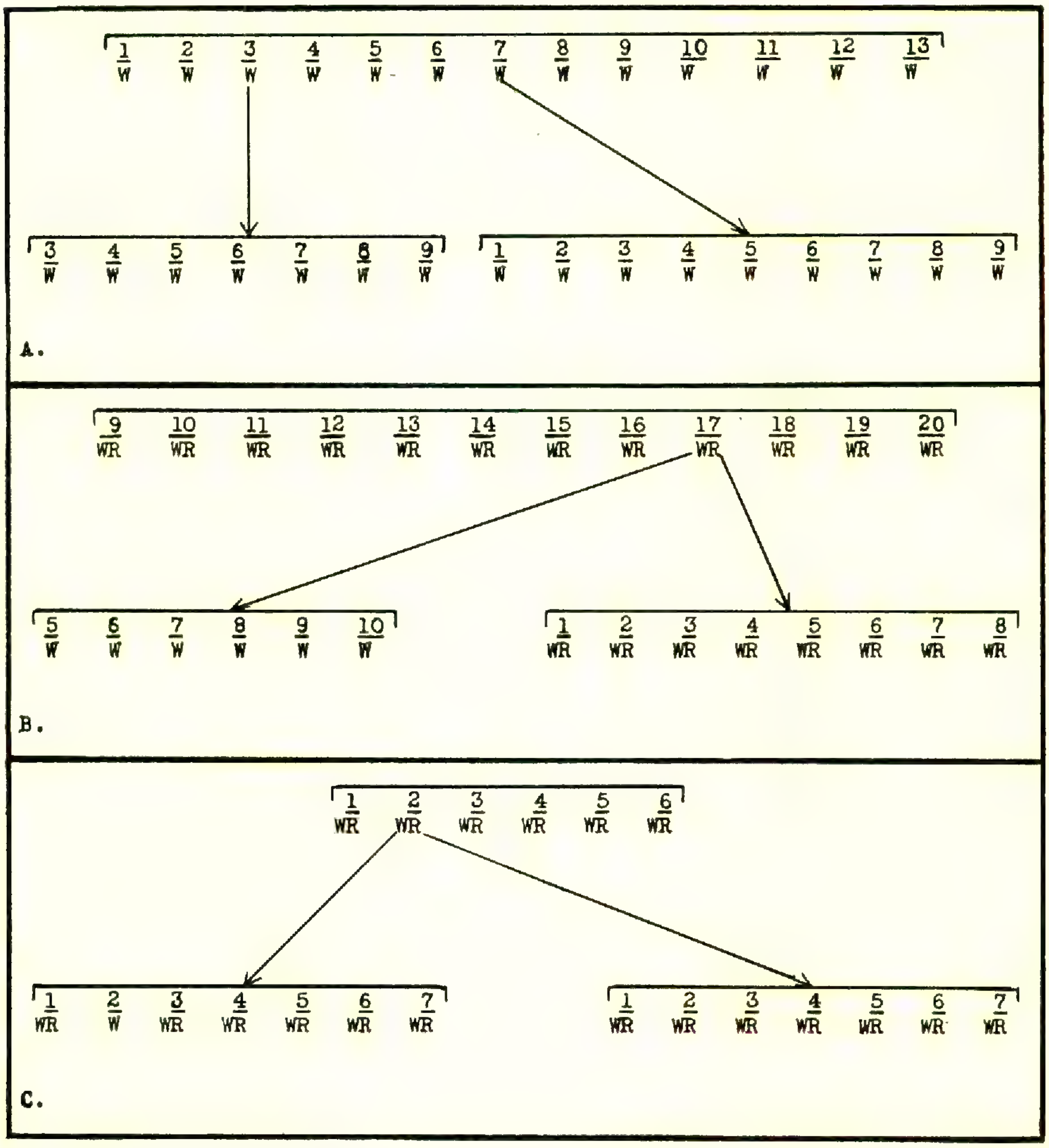

Fig. 1. Occurrence and transmission of cultural variants in single cell colonies of *Torulopsis pulcherrima*. (Explanation in text.)

colonies indicates that the chemical composition of this substratum appeared to play no rôle in pigment production (Porchet 1938), although Beijerinck (1918) and Castelli (1940) have advanced the idea that the formation of pigment in *T. pulcherrima* is dependent upon traces of iron salts in the medium.

However, three distinct exceptions to this phenomenon of variation were found to occur in about ten percent of the cases. In the first type, twenty-

four single cells, each derived from the marginal area of pigmented portions of parent colonies, gave rise to wholly pigmented sub-colonies which failed to develop any visible white sectors. One of these pure red colonies was subcultured, the five derived single cell colonies also being pigmented and failing to show any variation. Further subculturing from one of these resulted in five more completely red colonies. Thus, the red cultural type was not found to be completely unstable, although the possibility exists that these apparently constant red types may have produced white sectors in portions of the colony other than the surface layers and consequently were not apparent to the eye.

The second exception to the normal type of variation was the production of two small brownish sectors in the red portion of a sectored colony derived from a single cell. Single cells isolated from these brown sectors gave rise to colonies of the normal red color. It is concluded that the brownish sectors were merely temporary variants, the formation of which, therefore, presumably did not involve a mutational change (Snyder and Hansen 1939).

The final type of irregularity in cultural behaviour involved the appearance of a red pigment in single cell colonies which were derived either from the white sectors of pigmented colonies (Figure 1C) or from pure white colonies. It should be noted, however, that a preliminary examination indicated that this pigment was perhaps not identical with the normal type in that its color was usually a deeper red and it appeared to lack diffusibility. This type of variation, although of comparatively rare occurrence, is nevertheless of utmost significance in regard to the interpretation of the results of this study of cultural variation in *T. pulcherrima* as will be noted in the following discussion.

In attempting to explain the occurrence and transmission of cultural variation observed in single cell colonies of *T. pulcherrima*, emphasis should be placed upon the distinctive nature of the dissociation, in that white to white and red to red and white appeared to be the normal behaviour. This is in confirmation of the work of Punkari and Henrici (1933, 1935) who state, ". . . red is much less stable than white. It has been possible to maintain pure reds through three generations in 2 lines by selective subculturing. But white sectors appear so frequently in red colonies that we believe it will be impossible, under the conditions of this experiment to maintain a pure red line indefinitely." The lack of sporulation in their cultures was justifiably regarded by Punkari and Henrici as proof of absence of sexual reproduction, and they therefore concluded that the observed dissociation bore no relation to hybridization or to any other phase in a life cycle involving sexuality.

A possible explanation for the observed variation may lie in the investigations of Hansen (1938) on the dual phenomenon, in which a dual fungus is regarded as one which is composed of two distinct cultural homotypes, M (mycelial) and C (conidial), which may not be recognized until their separation from the heterotype MC is accomplished by single spore or single cell technique. Hansen stated that "the dual phenomenon is due to hetero-

caryosis, i.e., that individual cells and individual spores of dual fungi contain two genetically distinct types of nuclei," and he further stated in 1942 that "two factors or mechanisms operate against the possibility of the uninucleate condition being continuous or permanent," the two factors being mitosis and anastomosis. Heterocaryosis is believed to be initiated by "(1) mutation within a plurinucleate entity, and (2) by fusion or anastomoses between cells having genetically unlike nuclei." Hansen and Snyder (1943) in discussing the relationship between the dual phenomenon and sex in a species of *Hypomyces* found that in many cultures an M homotype of extreme stability arose *de novo* in C homotypes with great frequency and regularity and that the M type never reverted to the C type. They concluded, as a result of crossing behaviour, that "the change of C to M is a true genetic mutation, that it is a unidirectional one, apparently common to fungi in general. . . .," and "that this mutation may be the cause of the dual phenomenon in all fungi where this condition occurs." Although the regular appearance of white sectors in red colonies of *T. pulcherrima* is certainly indicative of a unidirectional mutation, the actual proof of this assumption would necessarily lie in crossing experiments involving the inheritance of the factor for white sectors. Although this has not been demonstrated in this organism, it is nevertheless obvious that the stable white variant obtained in culture may be considered analogous to the mutating C homotype of these authors. In view of the uncertainty in regard to the nuclear condition in this species, the designation of the original mass isolate in regard to M and C would be a matter for speculation.

However, the exception to the normal dissociation involving the production of red from white does not support the interpretation of the variation in this organism as being an expression of the dual phenomenon because of its reversibility. Rather, it is indicative of Punkari and Henrici's "reversion to ancestral forms" (1933), in which they found that a pure white colony derived from a white sector gave rise to a mixed red and white subcolony. However, if this pigment arising in white colonies is found to be of a different nature than the normal type, the concept of reversion would not apply, and the normal dissociation could then be regarded with a degree of certainty as an expression of the dual phenomenon. Studies on this phase of the problem are now in progress.

One further point in regard to the production of pigment, regardless of its nature, in colonies derived from white sectors is of significance. Actual dissection of a three-month-old sectored colony revealed that the sector did not extend throughout the entire depth of the colony. The relatively small size of the colony and its sector made this relation rather difficult to determine, but further evidence of its existence was obtained by making mass transfers of cells from different portions of the dissected colony. It was found that transfers of cells from the base of the colony directly underneath the white sector gave rise to subsequent pigmented colonies, indicating that the white sector did not actually extend to the bottom of the colony. It is conceivable that if a transfer needle were plunged rather deeply into a sector

of this type, the cells transferred could be a mixture of both the non-pigmented and the pigmented types, and that single cell isolations could therefore give rise to both types. Further dissection of other sectored colonies of both *T. pulcherrima* and *T. deformans* revealed that the depth of the sectors may range from superficial layers of cells to an entire wedge of the colony, emphasizing the fact that accurate interpretation of results may be dependent upon the actual depth to which the transfer needle is inserted into the sectored portions of the colony. In this connection, Christensen (1940) has stated, "Sectors are not necessarily pure for type because mutants may grow either over or under the parent, and subcultures from such sectors may consist of the mutant plus the parent line." Whether or not these facts may be correlated with the apparent reversion noted from white to red is unknown, since the dissections were made on sectored colonies from other series; these facts are offered, however, as a possible explanation, although, of course, they would not apply to the production of pigment in colonies derived from pure white cultures.

Thus, it appears that because of the possibility of the occurrence of reversibility, the dual phenomenon may not be the correct explanation for the cultural variation occurring in *T. pulcherrima*. Regardless of interpretation, however, the observed facts still point to this variation as being of a distinctive type in that it has been found to be predominantly unidirectional, stable, and predictable, and, as will be discussed later, is associated with significant differences in cellular morphology.

ANALYSIS OF SINGLE CELL CULTURES OF T. DEFORMANS

The previously noted variants occurring in the form of colonial sectors in monosporous cultures of *T. deformans* were subjected to a single cell analysis similar to that made for *T. pulcherrima* in order to obtain additional information in regard to their transmission and stability. Because of the number of monosporous isolates on hand, a series of single cell isolations, each involving one or more generations, was made from each of six monosporous sectored cultures; whereas in the analysis of the cultural variants of *T. pulcherrima*, a single sectored colony had been used as the basis for all subsequent single cell work.

The single cell colonies obtained in this manner exhibited, as a group, the same range of variation in pigmentation which had been observed in their ancestral monosporous cultures, as well as a sporadic tendency to produce roughened surface areas which appeared to bear no relation to the pigmentation, and which were characterized by numerous small papillae.

Transmission of two (white and yellow) out of the three variants observed was noted, while the third type, which was characterized by various modifications in intensity of the normal pink colony color, did not appear to be transmissible. It should be noted, however, that this third type was often evident only as a slight deviation from the normal color, pale grayish vinaceous. Consequently, although quite evident in its original appearance as a colonial sector, its later recognition in sub-cultures involved some

difficulty. In spite of this, it should be emphasized that no positive evidence was obtained for the transmission of this sector type (designated as *b*), because all single cells derived from *b* sectors gave rise to colonies the color of which appeared to be essentially similar to the normal type (*a*). It is

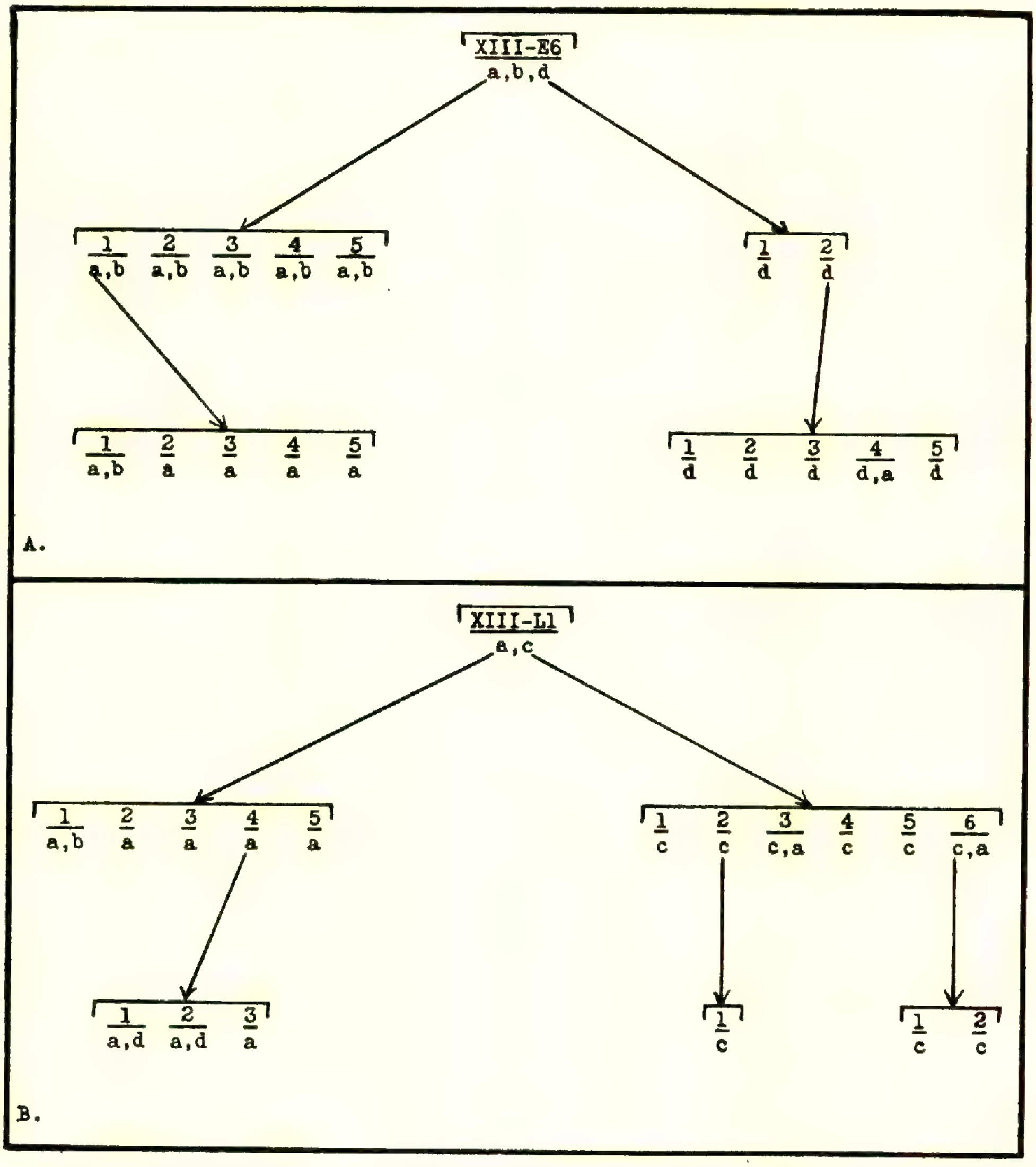

Fig. 2. Occurrence and transmission of cultural variants in single cell colonies of *Taphrina deformans*. (Explanation in text.)

therefore concluded that sectors of the *b* type were temporary variants which consequently were not produced by mutational changes.

Transmission of the other two variants is shown in Figure 2 which diagrammatically represents the single cell analysis made of two monosporous sectored colonies, XIII–E6 and XIII–L1. In these diagrams, as in those for *T. pulcherrima*, each numeral represents an individual colony,

and each group of numerals enclosed in a bracket represents a series of single cell colonies derived from that portion of the parent colony at which the arrow originates. The actual appearance of the colonies is indicated by the following symbols: *a*, the normal color, pale grayish vinaceous; *b*, modifications of *a* either by greater or lesser intensity of color; *c*, non-pigmented or white; and *d*, mustard or Naples yellow. When these letters are combined under one numeral, that colony consisted of the color indicated by the first letter, with sectors of the variant type(s) so designated.

Figure 2A exhibits three points worthy of note: (1) the transmission of the yellow variant *d*; (2) the incomplete stability of *d*, as seen by its dissociation in one colony to an *a* variant; and (3) the sporadic production of *b* variants in the normal *a* type.

Figure 2B exhibits similar phenomena: (1) the transmission of the white variant *c*; (2) the incomplete stability of *c*, as seen by its dissociation into *a* variants; and (3) the sporadic production of variants *b* and *d* in the normal *a* type.

These observations point to the main distinction apparent between the cultural variation of *T. deformans* and *T. pulcherrima* — namely, the regularity with which the latter produces a single variant as contrasted with the sporadic production of two variants by the former organism. In addition, the apparent reversion of the white variant to the parent type as observed in *T. pulcherrima* was of comparatively rare occurrence when contrasted with the abundant reversions to the normal type occurring in the variants of *T. deformans*. The two organisms are similar with respect to the production of temporary variations in the form of non-transmissible sector types — namely, the *b* variant of *T. deformans* and the brown variant of *T. pulcherrima*.

It is therefore concluded that, while the observed cultural variation in *T. pulcherrima* may possibly be regarded as an expression of the dual phenomenon, no such interpretation can be inferred from the evidence obtained from *T. deformans*. As has been previously noted, the regular occurrence of the white variant in the red cultural type of *T. pulcherrima* is indicative of a true mutation, but actual proof from inheritance studies is lacking. Likewise, crossing experiments are not possible with the homothallic *T. deformans*, so that the inheritance behaviour of the variants are unknown. In addition, the single cell analyses performed with *T. deformans* were not so extensive or of such long duration as to preclude the possibility that the yellow and the white transmissible variants may also be only temporary. As Snyder and Hansen (1939) have pointed out, "They (temporary variations) may result from some factor in the environment . . . and eventually revert to the parent type with the return of original conditions. Reversion, however, may be slow and the variants give a semblance of permanency." However, if they are to be regarded as true mutants, and the fact that they arose from monosporous cultures derived from haploid uninucleate cells is good evidence that they may well be (Christensen 1940), it should be emphasized that their spontaneous and unpredictable occur-

rence would seem to preclude the possibility of their being an expression of the dual phenomenon.

MICROSCOPIC EXAMINATION OF CULTURES

The general morphology of the cells of both organisms in culture was found to be essentially similar to the descriptions given by previous investigators, such as those of Mix (1935) on *T. deformans* and those of Lodder (1934) on *T. pulcherrima*.

Young cultures of both fungi maintained on potato dextrose agar at room temperature were composed of round to oval, thin-walled cells which reproduced vegetatively by typical budding. Both organisms produced cells of similar shape, although those of *T. pulcherrima* showed a tendency to become more globose than did those of *T. deformans*. The range in cell size was found to be similar to that previously reported for *T. deformans* (2.4–6.3 x 3.6–8.6 μ, Mix 1935) and for *T. pulcherrima* (3.0–4.5 x 3.5–6.5 μ, Lodder 1934), although somewhat larger cells were occasionally found in young cultures of the latter. The main distinction in cellular morphology between young cultures of the two organisms appeared to be in the production of oil (or fat) globules in the round cells of *Torulopsis* and their absence in the cells of *Taphrina*. These oil globules, although showing quite a range in size, were characteristically quite large, often occupying almost the entire cell. Such round cells containing a single large oil droplet have been designated by Lodder as typical "pulcherrima cells," and, according to her, were noted in the original description of the species by Lindner (1887). Numerous other investigators (Beijerinck, 1918; Grosbusch, 1915; Punkari and Henrici, 1933) of this organism have also noted them. In the present study, their occurrence was noted in young cultures, but they were found to be much more abundant in older cultures, as will be discussed below.

Old cultures (one to three months) of both fungi were, in general, quite similar microscopically and showed few significantly distinguishing characters. In addition to the normal type of vegetative cells (Plate I, Fig. 9), the abundant production of large, thick-walled, globose cells was noted in both, those of *T. pulcherrima* appearing as typical "pulcherrima cells," while those of *T. deformans*, although of similar shape, were often larger and typically contained more than one oil globule (Plate I, Figs. 10, 11). The size of these cells varied considerably in both organisms, but all were larger than the vegetative budding cells, and some reached a diameter of 12 to 15 μ. As previously mentioned, the occurrence of these large thick-walled cells in *T. pulcherrima* has been noted by many investigators, while Pierce (1900), Fitzpatrick (1934), Mix (1924, 1935), and Martin (1925, 1940) have observed them in *T. deformans*. Their significance will be discussed later.

SPORULATION

Previous reference has been made to the work of Windisch (1938, 1940), in which sporulation was reported for the first time in *T. pulcherrima*. The

results of the following microscopic investigation of this organism are offered in partial confirmation of Windisch's observations.

As previously noted, large thick-walled cells containing a single oil globule were observed to be extremely abundant in old cultures of *T. pulcherrima* on both potato dextrose and vegetable agar. In addition, it was found that many of these cells possessed what appeared to be the attached remnant of a cell wall. In view of Windisch's interpretation of similar structures representing stages in the life cycle of this organism, it was decided to investigate the species more fully for the occurrence of sporulation in culture.

It will be recalled that Windisch had observed in "pulcherrima cells" the formation of bud-like protrusions into which passed a portion of the divided oil globule and in which four spores were subsequently formed. The rupture of the protruded daughter cell liberated the spores, the remnant of this cell remaining attached to the mother cell, often for long periods of time. Copulation between cells derived from the budding of the ascospores occurred and resulted in the eventual formation of the large, thick-walled "pulcherrima cells."

Although not all stages in this life cycle were found, the following structures, believed to represent the sporulation process, were noted in both mass and single cell cultures (Plate I, Figs. 12–14; Plate II, Figs. 1–5):

Thick-walled "pulcherrima cells" with

1) papillate protrusions
2) attached daughter cells, some of which contained oil globules
3) attached daughter cells which contained one to three spore-like bodies
4) attached remnants of ruptured daughter cells

Although not clearly evident in the photomicrographs, the small bodies occurring in the attached daughter cells were readily distinguished from oil globules by the fact that they were less refractive. In addition, a small dark area, interpreted as a small oil droplet, is apparent in these bodies. It is concluded that these structures are actually spores, and that all of the structures listed above represent phases of the sporulation process. In this connection, it should be noted that the morphology of these structures was essentially similar to that described and illustrated by Windisch.

Windisch's observations on the budding of the ascogenous cells were also confirmed. He states, "Die Mutterzelle sprosst wieder aus; noch während der erste Ascus aufsitzt, kann sie durch Sprossung eine oder mehrere Tochterzellen hervorbringen, von denen sich nicht sicher entscheiden lässt, ob sie nun auch Asci werden oder Sprosszellen bleiben sollen." Such a phenomenon is illustrated in Plate II, Fig. 6, which represents the development in twenty-four hours of a "pulcherrima (ascogenous) cell" with attached, empty daughter cell (ascus), both of which had been separated together from the margin of a colony by the micromanipulator. It will be noted that in this particular case two cells have been formed from the ascogenous cell at the opposite side from the empty ascus. No further growth occurred.

Figure 6 of Plate II is also of significance in that it reveals a morphological distinction between normal buds and those buds which are believed to represent asci. It will be seen from this figure that the two vegetative cells are somewhat constricted at their bases, while the assumed ascus has a comparatively large, unconstricted base. This distinction between typical buds and asci was quite characteristic in the cultures examined and was used as a basis for differentiation in the absence of spore-like bodies.

Unfortunately, the isolate of *T. pulcherrima* used in these studies had been maintained as a stock culture for several years prior to the present investigation and appeared to be losing its sporulating ability. As a result, comparatively few spores were found, and it was not possible to study the actual sequence of events in the sporulation process of individual cells, as did Windisch. Also, Windisch had found quite consistently spores in groups of four, while in the present study, three spores were the most found in one cell. Spore discharge and germination were not observed.

A few indications of copulation of vegetative cells were noted. One non-pigmented colony was found to consist of cells which appeared to be copulating with the formation of conjugation tubes (Plate II, Fig. 7). In another non-pigmented colony, two cells were seen which were in such a position as to be indicative of the copulation process.

Windisch observed sporulation in *T. pulcherrima* and subsequently suggested the relationship of this organism to members of the genus *Taphrina* on the basis of the latter's sporulation as it occurs on the host plant. In view of this fact, it was decided to make an intensive study of the cellular morphology of *T. deformans* in culture in order to determine whether Windisch's views on the similarity of the two organisms could be further substantiated.

One- to three-month-old cultures of the fungus on potato dextrose and vegetable agar were examined microscopically and revealed the presence of large thick-walled cells containing one to many oil globules, with, in addition, attached structures similar, if not identical, to those noted above for *T. pulcherrima* (Plate II, Figs. 8–10; Plate I, Fig. 11).

The similarity of these structures to those observed in old cultures of *T. pulcherrima* is readily seen from the photomicrographs, and it is believed that the bodies occurring in the attached daughter cells of *Taphrina* may also be regarded as spores, and that likewise the attached structures may represent phases of the sporulation process. As in *T. pulcherrima*, it will be seen that each of the spore-like bodies contains what appears to be one or two small oil globules. The discharge of these bodies was not observed.

The occurrence of this apparent sporulation in *T. deformans* in culture has two significant aspects — first, it lends support to Mix's report of the occurrence of the diplophase of *T. deformans* in culture, and secondly, it further substantiates Windisch's conception of a relationship between *T. pulcherrima* and the Taphrinales.

In 1924 Mix observed large, thick-walled cells in old cultures and designated them as "resting spores." He noted that in germination they "may

burst, allowing the escape of a thin-walled protoplast, a behaviour similar to that of the ascogenous cells found in the leaf," and, in agreement with Pierce (1900), he suggested that "the resting spores developed in culture may indicate an approach to the ascigerous stage." In 1929, he reported in an abstract that the resting cells are believed to be ascogenous cells and that "structures believed to be imperfect asci have also been found." In 1935 further emergences from the germinating resting spores were noted and interpreted as asci, some of which were found with "2 and 3 fully formed spores." Other workers, such as Martin (1940) and Fitzpatrick (1934) have noted similar large, thick-walled cells in culture, but have not ascribed to them the character of ascogenous cells, for no structures resembling asci were found. Although Mix's assumed asci were comparable in size and shape to the normal asci occurring on the host, it is believed that the smaller attached daughter cells containing spore-like bodies noted here may also be regarded as imperfect asci with ascospores, and that consequently the large, thick-walled mother cells may be interpreted as ascogenous cells. It is interesting to note that the large thick-walled cells were found in both mass and monosporous cultures of *T. deformans*, indicating, as Martin (1940) has recently pointed out, that "their formation is evidently not dependent upon conjugation."

It will be recalled that Windisch interpreted the "pulcherrima cells" of *T. pulcherrima* as ascogenous cells and the bud-like protrusions developing into daughter cells as asci in which ascospores were formed. The similarity between these structures occurring in culture and the ascogenous cells, asci, and ascospores of species of *Taphrina* was then pointed out, and resulted in the conception of a close relationship between *T. pulcherrima* and the Taphrinales. It is believed that the results of the present study provide further supporting evidence for this view, because of the fact that quite similar types of cultural sporulation in both *T. pulcherrima* and *T. deformans* have been observed.

COMPARATIVE CELLULAR MORPHOLOGY OF THE CULTURAL TYPES OF T. PULCHERRIMA

Both Porchet (1938) and Windisch (1940), although aware of the variation in pigmentation occurring in *T. pulcherrima*, worked with mass rather than with single cell cultures and consequently failed to obtain a complete separation of the two pure cultural types. As a result, their observations on cellular morphology were undoubtedly made, in part, on mixtures of cultural types and are therefore of little significance in a study of the comparative cellular morphology of the pigmented colonies and their non-pigmented variants. On the other hand, Punkari and Henrici (1933, 1935) by means of single cell technique were able to separate the white variant from the pigmented portion, and, as a result of microscopic examination, concluded (1933) that "no morphologic differentiation could be established between red and white variants." The evidence obtained from the present investigation of this phase of the problem indicates, to the contrary, that

some differentiation on the basis of cellular morphology is apparent between the two cultural types.

Microscopic investigations were made of all of the single cell colonies used in the work on cultural variation, each colony or sector being examined after it had been growing on potato dextrose agar for one month or longer. The results of this study showed that the red pigmented cultural type produced abundant thick-walled cells, often containing oil globules (Plate II, Fig. 11), while the white variants, both in the form of sectors and entire colonies, often lacked this tendency and consisted, for the most part, of smaller, thin-walled cells reproducing vegetatively by typical budding [4] (Plate II, Fig. 12). This phenomenon was first noted in the original mass sectored culture on potato dextrose agar. The results of subsequent microscopic examinations of single cell colonies derived from this ancestral culture are tabulated as follows:

	Number of Cultures Examined	Number of Cultures Containing Large Thick-walled Cells	Number of Cultures Containing Large Thick-walled Cells with Attached Daughter Cells
Red Cultural Type	44	40	31
White Cultural Type	141	10	3
Total	185	50	34

It should be noted that some cellular structures occurring in both the red and white cultural types were rather difficult to classify because of transitional stages in size and shape, due, it is believed, to the age of the culture and the portion of the colony from which the cells to be examined were taken. Furthermore, oil globules were not always apparent in the large cells, and for this reason they have not been designated as "pulcherrima cells" in the above tabulation. It is believed, however, that the large, thick-walled cells observed, either with or without oil globules, may be regarded as similar to those cells interpreted by Windisch as ascogenous cells, for many of them were found to possess attached daughter cells. Likewise, the attached daughter cells are considered to be asci, for several of these were found to contain spore-like bodies.

Because of the occurrence of large, thick-walled cells and attached daughter cells in some of the white variants, this tabulated evidence cannot

[4] In 1918 Beijerinck, working with mass cultures, noted that certain cells of *Saccharomyces pulcherrimus* (*Torulopsis pulcherrima*) failed to produce fat globules. This was considered to involve a mutational change; and such variants were designated as *S. pulcherrimus secundarius*. Although fairly constant, these so-called mutants were found to show in some cases a tendency to revert to the normal condition and were apparently not related to any constant directional change in pigmentation. Hence it is believed that this behaviour is not comparable to that which has been found in the present study, although the possibility exists that the results would have been similar if Beijerinck had employed single cell technique.

be regarded as implying a definite, constant distinction between the two cultural types on the basis of cellular morphology. It can be regarded, however, as indicative of different morphological *tendencies* in the two types. In view of Windisch's interpretation of these cellular structures, this evidence raises interesting implications in regard to the relationship between the life cycle of this organism and its cultural variation. Certainly, a tendency for the sexual stage to occur more frequently in the red cultural type is indicated here, but the complete answer to this problem must await the results of further investigations.

Although some secondary papillae and roughened surfaces were evident in several single cell cultures of *T. pulcherrima*, no detailed study of them was undertaken. It should be mentioned, however, that one pure white single cell colony produced two large craters, and microscopic examination of cells from both of them revealed the presence of long, septate mycelial strands. This is in confirmation of Punkari and Henrici's investigations (1935), in which they noted that craters were only observed in white colonies and stated that ". . . microscopic examination of colonies with craters always showed the presence of mycelium, which was not found in smooth colonies."

In addition, twelve white colonies or sectors, when examined microscopically, were found to consist of polymorphic cells, or of cells exhibiting a pseudomycelial tendency, and it was further noted that these were always associated with a roughened surface characterized by the formation of numerous small papillae.

COMPARATIVE CELLULAR MORPHOLOGY OF THE CULTURAL TYPES OF T. DEFORMANS

Similar microscopic investigations were carried out on all of the single cell colonies of *T. deformans* in order to determine whether any variation in cellular morphology existed, and if so, whether it bore any relation to the formation of the four cultural types previously designated on the basis of pigmentation as *a*, *b*, *c*, and *d*. All colonies were examined after they had been growing on potato dextrose agar slants for one month or more, and recorded descriptions were made of the general appearance of the cells, including the occurrence of large, thick-walled cells either with or without attached daughter cells. In view of the fact that spore-like bodies were found in several of these attached daughter cells, these cellular structures were regarded as being indicative of the sporulation process and were consequently interpreted as ascogenous cells, attached asci, and spores. As in the microscopic investigations of *T. pulcherrima*, some difficulty was encountered in accurately interpreting all structures observed because of the occurrence in some colonies of cells of transitional shape and size.

In general, it can be stated that these cellular structures indicative of sporulation occurred as abundantly as in *T. pulcherrima*, being found in 62 out of a total of 159 cultures examined. (Compare with tabulation totals for *T. pulcherrima*, page 366.) In contrast to the observations on *Torulopsis*,

however, no evidence was obtained in this study for a differentiation of the cultural types on the basis of cellular morphology, for these structures were found in representatives of all four cultural types. They appeared to be somewhat more abundant in the normal *a* type, but it is believed that they were found in sufficient numbers in the variants *b*, *c*, and *d* to preclude any generalization as to a constant relationship between sporulation and pigmentation.

These results seem to indicate, therefore, that in *T. deformans* cellular morphology, with regard to the occurrence of structures indicative of sporulation, appears to be more constant than in *T. pulcherrima*, in the sense that it shows no clear-cut differentiation into two types, each associated with a distinct pigmented cultural type. On the contrary, in *Taphrina*, the occurrence of cells indicative of sporulation may appear in any culture regardless of its pigmentation. It is possible that their occurrence may be correlated with the age of the culture, but this is offered only as a theoretical consideration, for no detailed study was made of this phase of the problem.

A tendency for mycelial production in culture, which is believed to be more pronounced than has previously been reported, was also noted in *T. deformans*. Long, septate hyphal strands very similar in appearance to the intercellular mycelium of this organism in host tissue were observed (Plate III, Figs. 1, 2). This tendency was noted in the normal type, as well as in the *b* variant and was not found to be associated in every instance with a roughened surface.

Other cultures of *T. deformans* were composed of elongated, rod-shaped, or otherwise irregularly shaped cells which were either single or in pairs. In addition, the formation of primitive pseudomycelium in the form of short chains was noted by both the normal and irregularly shaped cells. These pseudomycelial and polymorphic tendencies occurred in the normal pigmented type as well as in the *b* variant and were found either in association with roughened surfaces or independent of them. A tendency to produce elongated or rod-shaped cells was also noted in some of the smooth colonies of the yellow variant *d*.

NUCLEAR CONDITION

Considerable difficulty was encountered in obtaining a satisfactory nuclear stain for *T. pulcherrima*. The most successful stain employed was Laustsen's modification of the Feulgen technique, as described by Winge (1935). Windisch had apparently obtained very satisfactory results with this method, although no photomicrographs of stained preparations were included in his paper. He states (1940): "Kernfarbungen nach Winge-Feulgen mit Fuchsin erwiesen die Zweikernigkeit aller vegetativen Formen sowie der Ascusmutterzellen."

In the present study, cells from young, active cultures were the only ones stained satisfactorily by this method, and consequently no information as

to the nuclear condition of the large, thick-walled cells (ascogenous cells or ascus mother cells) occurring in old cultures was obtained. However, it was found that all vegetative cells, whether from mass or single cell, pigmented or non-pigmented cultures, were stained in such a way that they exhibited what is believed to represent a constant uninucleate condition. This is in direct contrast to the binucleate condition reported by Windisch.

Although some differences in interpretation of the stained bodies could be made, it will be seen from Plate III, Figs. 3, 4 that these stained preparations cannot possibly be regarded as being indicative of a binucleate condition, for each cell contains a single, deeply stained body. The difficulty in interpretation appears to involve the nucleoli and the nuclear membranes. A comparison of Plate III, Figs. 3, 4 with Figs. 11, 12, 13, 14, and 15 of Plate II in Winge's paper (1935) shows a definite similarity in the results of employing this staining procedure, notwithstanding the fact that two different yeasts were involved. Winge interprets, without question, the deeply stained bodies as nuclei, but it is possible that the stained bodies in our preparations may be nucleoli, because of the fact that some of them appear to be surrounded by a definite, clear area which is not apparent in Winge's photomicrographs. This clear area may possibly represent the extent of a single nucleus and the enclosed stained body, the nucleolus, but because no membrane is visible at the periphery of the clear area, this interpretation is doubtful. Regardless of the interpretation of the nuclear details, the results of this staining method clearly indicate that the young vegetative cells of *T. pulcherrima* are uninucleate.

In contrast, all of Windisch's stained preparations revealed a binucleate condition of the cells. Consequently, he believed that the uninucleate, haploid phase of the life cycle must be of very short duration, the derivatives of the ascospores copulating very soon after spore discharge, resulting in the establishment of the binucleate stage. Windisch actually observed this fusion of ascospore derivatives (which appeared to involve dissimilar partners and therefore can be considered as heterogamous copulation), but it should be emphasized that although this plasmogamy was found to result in the dicaryon phase, the actual point in the life cycle at which karyogamy occurred was not ascertained. Windisch had consistently observed a binucleate condition in the ascogenous cells and believed that these two nuclei corresponded to the nuclear pair observed in the vegetative cells. The possibility that the two nuclei were diploid daughter nuclei of a zygote nucleus was offered, but because, under certain conditions, the ascogenous cells could reproduce vegetatively by budding instead of forming asci, led Windisch to prefer the assumption that the two nuclei in the ascogenous cell were haploid. Because uninucleate ascogenous cells were never observed, Windisch proposed the idea that karyogamy in *T. pulcherrima* may occur in the ascus, and as evidence of a similar occurrence in the Taphrinales, he referred to the statement of Kniep (1928) that in *Taphrina*

nuclear fusion occurs in the ascus. However, it has recently been definitely established by Martin (1940) that karyogamy in *T. deformans* occurs only in the ascogenous cells, a fact which has been generally regarded as typifying the genus as a whole (Eftimiu 1927, Gäumann and Dodge 1928).

It is therefore believed that Windisch's assumption of a similarity between *T. pulcherrima* and *Taphrina* spp. based upon the nuclear condition in the life cycles of these organisms is incorrect. The possibility exists, of course, that karyogamy does occur in the ascogenous cells of *T. pulcherrima* and that Windisch had failed to observe it; but until this fact is actually known, a concept of a relationship between *Torulopsis* and *Taphrina* on the basis of the nuclear behaviour known at present does not appear to be justified.

The Laustsen modification of the Feulgen technique was not found to be satisfactory for demonstrating the nuclei in cells of *T. deformans*. None of the stains employed was found to be completely successful, although the use of Mayer's haem-alum demonstrated the presence of a single stained body in some of the sprout conidia from young cultures. Although no detail was apparent in any of these bodies, they were regarded as being indicative of a uninucleate condition, in view of the fact that several investigators (Fitzpatrick 1934, Martin 1940, Mix 1935) have found this to be the case in the majority of cells from young cultures of *T. deformans*.

Because, as in *Torulopsis*, only active cells from young cultures were successfully stained, no information on the nuclear condition of the larger, thick-walled cells (ascogenous cells) was obtained, although Mix reported them as being either uni- or binucleate (1935). In addition, Fitzpatrick (1935) observed some binucleate sprout conidia taken from fairly old cultures, while Wieben (1927) found in *Taphrina* spp. binucleate conidia following copulation. In the present study, no binucleate cells were observed.

PHYSIOLOGICAL TESTS

Although comparative observations of the microscopic and macroscopic appearances of the two fungi in culture represented the main problem in the present investigation, a limited number of tests were performed in order to determine some of the physiological differences between the two organisms as well as between the variant cultural types of each organism.

One of the most important distinctions between the physiology of *T. deformans* and *T. pulcherrima* is that the former has been reported to lack the ability to produce alcoholic fermentation (Mix 1924), while *T. pulcherrima* is a species capable of fermenting glucose, fructose, and mannose (Lodder 1934). Mix in 1924 used 10% solutions of dextrose, sucrose, and maltose in potato broth in his fermentation tests and had obtained completely negative results. Confirmation of this work was obtained by the failure of active mass and single cell cultures of *T. deformans* to produce any fermentation of 2% solutions in yeast juice of galactose, glucose,

maltose, lactose, and sucrose. In addition, the three variant types, *b*, *c*, and *d* were found unable to cause fermentation of any of these sugars.[5]

Because of this lack of fermentative ability in *Taphrina*, tests were performed by means of the auxanogram method (Lodder 1934) in order to determine what sugars this organism was capable of assimilating under aerobic conditions. Positive results were obtained with glucose and sucrose, and negative results with galactose, lactose, and maltose.

T. pulcherrima, on the other hand, was found to be capable of fermenting a 2% solution of glucose. In addition, the appearance in some of the sucrose solutions of a few gas bubbles was noted, which may be regarded as being indicative of a slight tendency of this organism to ferment this sugar. However, the explanation for the occurrence of gas bubbles in the sucrose solutions may lie in the method of sterilization of the liquid media. As Mudge (1917) pointed out, disaccharides may become hydrolyzed by sterilization in both the autoclave and the Arnold sterilizer, resulting in the formation of monosaccharides in the medium. Mudge found this to be the case with maltose and lactose, and the possibility exists that the sucrose solutions used in the present tests were sterilized for a length of time sufficient to induce a partial breakdown into the monosaccharides glucose and fructose, both of which are fermented by this organism. It should be noted, however, that, although Lodder in her standard work on generic and specific determination of the imperfect yeasts lists glucose (fructose, mannose) as the only sugar fermented by *T. pulcherrima*, Grosbüsch (1915) found that a strain of *Torula rubefaciens* (*Torulopsis pulcherrima*) was able to cause a very slight fermentation of sucrose.

Galactose, lactose, and maltose gave negative results in all fermentation tests with *T. pulcherrima*. In addition, no differences in fermentative ability were found between the red and the white cultural types.

Nitrogen utilization tests were undertaken by means of the auxanogram technique. Both the red and the white cultural types of *T. pulcherrima* were found capable of utilizing only asparagine and peptone, although Lodder had obtained, in addition, positive results with ammonium sulfate and urea. In this connection, it is worthy of note that in the original unpublished identification of this isolate of *T. pulcherrima*, ammonium sulfate was found by E. M. Mrak to be slowly utilized, while urea was not utilized at all.

No positive results for the utilization of any nitrogen-containing substances by *T. deformans* were obtained by means of the auxanogram method. In view of the fact that peptone is generally utilized as a nitrogen source by yeasts, as well as ammonium sulfate (Henrici 1941), these results are surprising. Moreover, in the sugar auxanograms, ammonium sulfate was the only nitrogen source available in the basal medium and therefore must have been utilized by *T. deformans* as evidenced by its growth in the

[5] According to the well-known "Kluyver-Dekker laws" (as cited by Henrici 1941), any yeast which can ferment glucose can also ferment fructose and mannose. For this reason, fructose and mannose were not included in the fermentation tests.

presence of glucose and sucrose. It is concluded that the complete explanation of these negative results must therefore await the results of further investigation.

In general, the physiological tests, although limited in scope, appear to point to two facts worthy of consideration: 1) *T. pulcherrima* can be distinguished from *T. deformans* on the basis of its ability to ferment certain sugars, and 2) on the basis of these tests, no differences in physiological behaviour were found between the two cultural types of *T. pulcherrima* and among the four cultural types of *T. deformans*.

DISCUSSION AND CONCLUSIONS

As evidenced by cultural similarities, the results of this investigation point to the apparent interrelationship of a saprophytic yeast, *Torulopsis pulcherrima*, and a parasitic fungus possessing a yeast-like saprophytic stage, *Taphrina deformans*.

It will be recalled that this comparative study was undertaken with the hope of obtaining additional information which could be used either in substantiation or in rejection of Windisch's concept of a relationship between *T. pulcherrima* and the genus *Taphrina* and his proposal to incorporate *T. pulcherrima* in the order Taphrinales as *Candida pulcherrima*. This proposal was based upon the similarities between the observed life cycle, including sporulation, of *T. pulcherrima* and of *C. tropicalis* in culture and the previously described life cycles of *Taphrina* spp. in their parasitic, non-culturable stages. Windisch made no recorded observations on the cultural characteristics of any species of *Taphrina*. In the present study, the genus *Candida* was not investigated, and while *T. deformans* was the only species of *Taphrina* used, it is believed to be representative of the general cultural behaviour of the genus as a whole.

For purposes of comparison, the information obtained from a study of the two fungi in culture may be tabulated as follows:

That the two fungi are, in general, quite similar in cultural behaviour is clearly evident from the above tabulation. In both organisms cultural variation may occur in the form of variously pigmented, transmissible or non-transmissible growth types; cellular morphology is of a similar type, pseudomycelium or true mycelium may be found, and cellular structures indicative of sporulation frequently occur. This latter fact is regarded as one of importance for the following reasons: 1) it confirms Windisch's report of sporulation in *T. pulcherrima* and consequently justifies the removal of this organism from the imperfect yeasts; 2) it supports Mix's observations on the occurrence of the diplophase and sexuality in *T. deformans* in culture; and 3) it offers additional support for the view of a general relationship between *T. pulcherrima* and the Taphrinales. Moreover, the finding of pseudomycelium and true mycelium in *T. pulcherrima* is indicative of the fact that it does not properly belong in the sub-family Torulopsidoideae as defined by Lodder (1934).

	T. pulcherrima	*T. deformans*
Character of cultural growth	Yeast-like	Yeast-like
Characteristic color of colony	Red — non-carotinoid, diffusible pigment	Pink — non-carotinoid, non-diffusible pigment
Occurrence of variation in pigmentation	White, brown	White, yellow, and various modifications of pink
Occurrence of transmissible variants	Predictable occurrence of white sectors	Unpredictable occurrence of yellow and white sectors
Occurrence of temporary variants	Unpredictable, rare occurrence of brown sectors	Unpredictable, frequent occurrence of sectors of various modifications of pink
General appearance of cells from young cultures	Oval-globose, thin-walled, budding cells and "pulcherrima cells"	Oval-globose, thin-walled, budding cells
General appearance of cells from old cultures	Mainly "pulcherrima cells"	Similar large, thick-walled cells but with many oil globules
Occurrence of cellular structures indicative of sporulation	Abundant in old cultures and interpreted as ascogenous cells, attached asci, and ascospores	Abundant in old cultures and interpreted as ascogenous cells, attached asci, and ascospores
Occurrence of differences in cellular morphology among the various cultural types	Evident in red and white cultural types	Not evident
Occurrence of a mycelial tendency	Present	Present
Nuclear condition of young vegetative cells	Uninucleate	Uninucleate
Fermentative ability	Ferments glucose	Incapable of fermenting glucose or any other sugar
Occurrence of physiological differences among the various cultural types	Not evident	Not evident

It will be noted from the above tabulation that the chief distinguishing points between the two organisms appear to involve the type of pigmentation and the fermentative ability, but it is known that both fungi may produce a non-pigmented growth type and that the genus *Torulopsis* contains several species which lack the ability to produce alcoholic fermentation (Lodder 1934). *T. deformans*, although customarily isolated from its host by means of discharging ascospores, also may be isolated in its overwintering, saprophytic stage from peach bark or buds; it is possible that confusion in identification would result if such isolates were studied according to the present methods for the determination of yeasts, without the use of inoculation tests.

Thus, in partial support of Windisch's views, it can be said that the

cultural similarities evident between *T. pulcherrima* and *T. deformans* are indicative of their interrelationship, an assumption which is believed to be further justified by the sporulation phenomenon, which was previously reported for *T. pulcherrima* by Windisch (1938, 1940) and which, in the present study, appears to have been confirmed for that species, and, in addition, to have been found in *T. deformans*.

However, certain other facts, as yet unexplained, have been revealed by this comparative investigation which do not lend themselves to a complete substantiation of the proposals of Windisch.

Specifically, all of the evidence obtained in this study is indicative of a constant uninucleate condition in the young vegetative cells of both *T. deformans* and *T. pulcherrima*, in contrast to Windisch's report of a constant binucleate condition in *T. pulcherrima* (exclusive of an assumed, very short, uninucleate phase). This discrepancy, coupled with Windisch's belief that karyogamy in this fungus occurs in the ascus, does not support the concept of a relationship between *Torulopsis* and *Taphrina* based upon nuclear behaviour. It is believed that perhaps the explanation for this discrepancy may lie in the use of single cell technique in the present study, and the subsequent distinctive type of variation in pigmentation which it revealed. It was found, in contrast to the investigations of Punkari and Henrici, that dissociation in *T. pulcherrima* into the two cultural types, regardless of whether it is an expression of the dual phenomenon, was apparently correlated with variation in cellular morphology, and that these distinct morphological tendencies seemed to bear some relation to the sporulation process, and therefore to sexuality. Consequently, until further cytological investigations of this organism reveal the complete facts surrounding the nuclear cycle, it seems unwise to point to the observed uninucleate condition of both *Taphrina* and *Torulopsis* in culture as being indicative of their interrelationship.

Thus, it is believed that these preliminary cultural investigations lend support to the ideas advanced by numerous investigators in regard to a general relationship between the yeasts and the Taphrinales. It is further believed that they also support the recent, more specific proposal of Windisch in regard to a relationship between the Taphrinales and *T. pulcherrima*, as well as the removal of the latter from the imperfect yeasts. However, because our knowledge of the cytology, sexuality, and variation of *T. pulcherrima* is still in an imperfect state, it is believed that further investigations of a wide number of isolates of this species are needed before it can be placed with certainty into any of the present schemes of classification of the perfect fungi.

It is therefore concluded that, although our present knowledge points to a relationship between *T. pulcherrima* and the Taphrinales, until the life cycle of the former has been completely worked out, especially with regard to the nuclear behaviour and the relationship between sexuality and cultural variation, the similarities recognized at present are not sufficient grounds for adopting Windisch's proposals of transferring *T. pulcherrima* to the

genus *Candida* and of incorporating it in the Taphrinales in a new family, the Candidaceae.

It should be added that no evidence was obtained from either organism which would fully support the findings of Todd and Herrmann in regard to their assumed life cycle of *Cryptococcus hominis* (*Torulopsis neoformans*) and that consequently the transfer of *T. pulcherrima* to the genus *Debaryomyces* has not been considered.

SUMMARY

1. Both *Torulopsis pulcherrima* and *Taphrina deformans* presented a similar yeast-like appearance when grown at room temperature on potato dextrose agar.

2. Both fungi produced a reddish or pinkish non-carotinoid pigment, that of *T. pulcherrima* being diffusible and that of *T. deformans* being non-diffusible.

3. In *T. pulcherrima* a predictable mutation-like change involving the production of white sectors occurred with great regularity in pigmented colonies. In *T. deformans* unpredictable sectoring involving a color change from pink to yellow or white occurred frequently but sporadically. The white variant of *T. pulcherrima* and the yellow and white variants of *T. deformans* were transmissible but did not possess complete stability.

4. Cellular morphology was essentially similar in cultures of both organisms, which were composed of single, ovoid to globose, budding cells. In addition, a mycelial tendency was noted in both organisms.

5. In old cultures of both fungi, cellular structures indicative of sporulation were noted and were interpreted as ascogenous cells, asci, and ascospores.

6. In *T. pulcherrima* a tendency for a differentiation of the red and the white cultural types on the basis of cellular morphology was noted and was found to be correlated with the sporulation phenomenon. In *T. deformans* no such morphological differentiation among the three cultural types was evident.

7. A constant uninucleate condition was found in the young vegetative cells of both fungi.

8. *T. pulcherrima* was found capable of fermenting glucose, while *T. deformans* was found incapable of causing fermentation. No evidence was obtained from either organism for the occurrence of any physiological differences among their various cultural types.

9. On the basis of these results, the interrelationship of *T. pulcherrima* and *T. deformans* is discussed, with especial reference to the recent proposal of Windisch in regard to the removal of *T. pulcherrima* from the imperfect yeasts to the Taphrinales.

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LITERATURE CITED

De Bary, A. Vergleichende Morphologie der Pilze, Mycetozoen, und Bacterien. Engelmann, Leipzig, 1884.

Beijerinck, M. W. Levures chromogènes. — Nouvelle réaction biologique du fer. Arch. Neerland. Physiol. Homme et Anim. **2:** 609–615. 1918.

Bessey, Ernst A. A Textbook of Mycology. Blakiston, Philadelphia, 1935.

————. Some problems in fungus phylogeny. Mycologia **34:** 355–379. 1942.

Castelli, Tommaso. Considerazioni sulla *Torulopsis pulcherrima.* Arch. Mikrobiol. **11:** 126–136. 1940.

Chamberlain, Charles J. Methods in Plant Histology. 5th rev. ed., University of Chicago, 1932.

Christensen, J. J. The origin of parasitic races of phytopathogenic fungi through mutation. *In* The Genetics of Pathogenic Organisms, Science Press (A.A.A.S.), pp. 77–82. 1940.

Eftimiu, P. Contribution à l'étude cytologique des Exoascées. Le Botaniste **18:** 1–154. 1927.

Fitzpatrick, R. E. The life history and parasitism of *Taphrina deformans.* Sci. Agr. **14:** 305–326. 1934.

Gäumann, Ernst A. & Carroll W. Dodge. Comparative Morphology of the Fungi. McGraw-Hill, N. Y., 1928.

Giordano, A. Studio micologico del *Debaryomyces neoformans* (Sanfelice) Red., Cif. et Giord. e significato delle specie nella patologia animale. Mycopathologia **1:** 274–304. 1938–39.

Grosbüsch, J. Über eine farblose, stark roten Farbstoff erzeugende *Torula.* Centbl. Bakt. II, **42:** 625–638. 1915.

Guilliermond, A. La sexualité, le cycle de développement, la phylogénie, et la classification des levures d'àpres les travaux récents. Extrait des Ann. des Fermentations **2:** 129, 257, 474, 540 (Paris, 1937).

Hansen, E. C. Grundlinien zur Systematik der Saccharomyceten. Centbl. Bakt. II, **12:** 529–538. 1904.

Hansen, H. N. The dual phenomenon. Mycologia **30:** 442–455. 1938.

————. Heterocaryosis and variability. Phytopath. **32:** 639–640. 1942.

———— & R. E. Smith. The mechanism of variation in imperfect fungi: *Botrytis cinerea.* Phytopath. **22:** 953–964. 1932.

———— & W. C. Snyder. The dual phenomenon and sex in *Hypomyces solani* f. *cucurbitae.* Amer. Jour. Bot. **30:** 419–422. 1943.

Henrici, Arthur T. The yeasts, genetics, cytology, variation, classification and identification. Bact. Rev. **5:** 97–179. 1941.

Kniep, Hans. Die Sexualität der niederen Pflanzen. Fischer, Jena, 1928.

Koch, L. W. Studies on the overwintering of certain fungi parasitic and saprophytic on fruit trees. Canad. Jour. Res. **11:** 190–206. 1934.

Lindner, P. Wochenschrift f. Brauerei, **4:** 853. 1887. (Cited from Lodder.)

Lodder, J. Die Hefesammlung des "Centraalbureau voor Schimmelcultures." Beitrage zu einer Monographie der Hefearten. II. Die anaskosporogenen Hefen. Erste Halfte. K. Akad. Wet., Verhand. (2nd Sect.) D1. **32:** 1–256. 1934.

Martin, Ella M. Cultural and morphological studies of some species of *Taphrina.* Phytopath. **15:** 67–76. 1925.

————. The morphology and cytology of *Taphrina deformans.* Amer. Jour. Bot. **27:** 743–751. 1940.

Mix, A. J. Biological and cultural studies of *Exoascus deformans.* Phytopath. **14:** 217–233. 1924.

————. Further studies on the Exoascaceae. Phytopath. **19:** 90. 1929. (Abstract).

————. The life history of *Taphrina deformans.* Phytopath. **25:** 41–66. 1935.

Mrak, E. M., H. J. Phaff, & H. C. Douglas. A sporulation stock medium for yeasts and other fungi. Science **96:** 432. 1942.

Mudge, Courtland S. The effect of sterilization upon sugars in culture media. Jour. Bact. **2:** 403–415. 1917.

Pierce, Newton B. Peach leaf curl: its nature and treatment. U.S.D.A., Div. Veg. Physiol. & Path. Bull. **20:** 204 pp. 1900.

Porchet, Berthé. Contribution à l'étude de la levure *Torulopsis pulcherrima*. Ann. des Fermentations **4**(7): 385–405. 1938.

Punkari, Laila & Arthur T. Henrici. A study of variation in a chromogenic asporogenous yeast. Jour. Bact. **26:** 125–138. 1933.

———. Further studies on spontaneous variations of *Torula pulcherrima*. Jour. Bact. **29:** 259–267. 1935.

Rawlins, Thomas E. Phytopathological and Botanical Research Methods. Wiley, N. Y., 1933.

Redaelli, P., R. Ciferri, & A. Giordano. *Debaryomyces neoformans* (Sanfelice) nobis, nov. comb., pour les espèce du groupe *Saccharomyces hominis-Cryptococcus neoformans-Torula histolytica*. Boll. Sez. Ital., Soc. Intern. Microbiol. I–II: 1–7. 1937. (Cited from Henrici). [Corrected citation, **9**(1–2): 24–28. 1937]

Reess, M. Botanische Untersuchungen uber die Alkoholgärungspilze. Leipzig, 1870.

Ridgway, Robert. Color Standards and Color Nomenclature. Author, Washington, D. C., 1912.

Snyder, William C. & H. N. Hansen. The importance of variation in the taxonomy of the fungi. 6th Pacific Sci. Congr., Proc. **4:** 749–752. 1939.

Todd, Ramona L. & Walter W. Herrmann. The life cycle of the organism causing yeast meningitis. Jour. Bact. **32:** 89–103. 1936.

Wieben, Magdalena. Die Infektion, die Myzelüberwinterung, und die Kopulation bei Exoasceen. Forsch. Geb. Pflanzenkr. u. Immunität **3:** 139–176. 1927.

Windisch, Siegfried. Zur Kenntnis der Ascosporenbildung bei *Torulopsis pulcherrima* (Lindner) Saccardo. Arch. Mikrobiol. **9:** 551–554. 1938.

———. Entwicklungsgeschichtliche Untersuchungen an *Torulopsis pulcherrima* (Lindner) Saccardo und *Candida tropicalis* (Castellani) Berkhout. Ein Beitrag zur Systematik der Gärungsmonilien. Arch. Mikrobiol. **11:** 368–390. 1940.

Winge, O. On haplophase and diplophase in some Saccharomycetes. Compt. Rend. Trav. Lab. Carlsberg, Ser. Physiol. **21:** 77–111. 1935.

EXPLANATION OF PLATE I

Fig. 1. *T. deformans.* Glass needle of micromanipulator drawing out a single cell from the margin of a colony. (135x).

Fig. 2. *T. pulcherrima.* A day-old colony originating from a single cell withdrawn from the margin of the parent colony by means of the glass needle of the micromanipulator. (135x).

Fig. 3. *T. deformans.* A 3-month-old colony on potato dextrose agar originating from a single ascospore. Note abundant sectoring. (Natural size).

Fig. 4. *T. deformans.* A 3-month-old colony on potato dextrose agar originating from a single ascospore. Note absence of sectoring. (Natural size).

Fig. 5. *T. pulcherrima.* A 3-month-old pigmented colony on potato dextrose agar originating from a mass transfer of cells from the pigmented portion of the original stock culture. Note formation of white sectors. (Natural size).

Fig. 6. *T. pulcherrima.* A 3-month-old white colony on potato dextrose agar originating from a mass transfer of cells from a white sector in the original stock culture. Note absence of pigmentation. (Natural size).

Fig. 7. *T. pulcherrima.* A month-old pigmented colony on potato dextrose agar originating from a single cell of the pigmented portion of a sectored colony. Note formation of white sectors. (Natural size).

Fig. 8. *T. pulcherrima.* A month-old white colony on potato dextrose agar originating from a single cell of a white sector. Note absence of pigmentation. (Natural size).

Fig. 9. *T. deformans.* Normal type of vegetative cells (sprout conidia) from a 2-month-old single cell culture. Unstained. (588x).

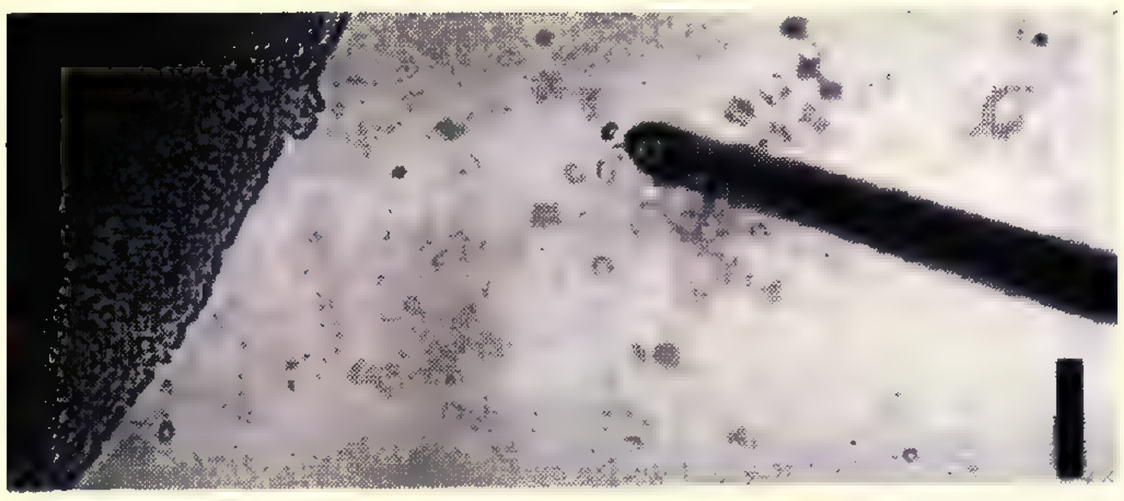
Fig. 10. *T. pulcherrima.* Typical "pulcherrima cells" from a month-old, pigmented, single cell culture. Note single oil globules, thick walls, and attached cell wall remnants. Unstained. (1200x).

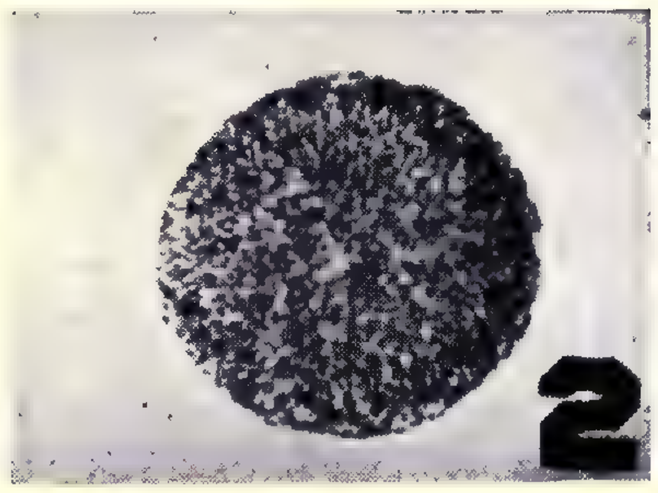
Fig. 11. *T. deformans.* Large thick-walled cell from a 4-month-old mass culture. Note numerous oil globules and the attached remnant of a cell wall. Unstained. (1101x).

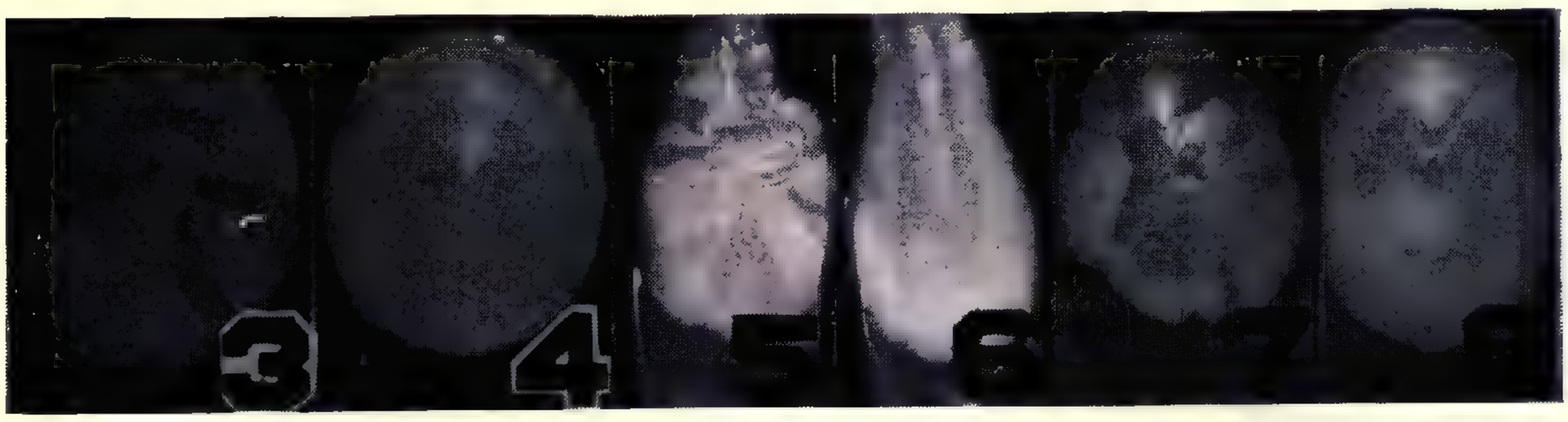
Fig. 12. *T. pulcherrima.* "Pulcherrima cells" from a pigmented, month-old, single cell culture, showing a papillate protrusion. Unstained. (1200x).

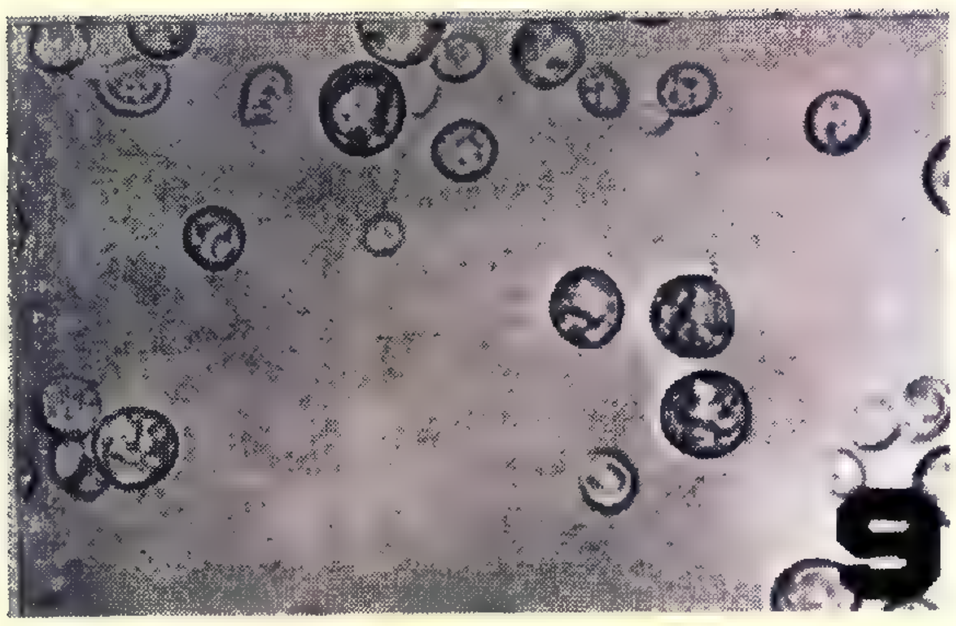
Fig. 13. *T. pulcherrima.* A "pulcherrima cell" from a pigmented, 4-month-old, mass culture, showing the attached daughter cell. Note that both mother and daughter cells contain a single oil globule. Unstained. (1101x).

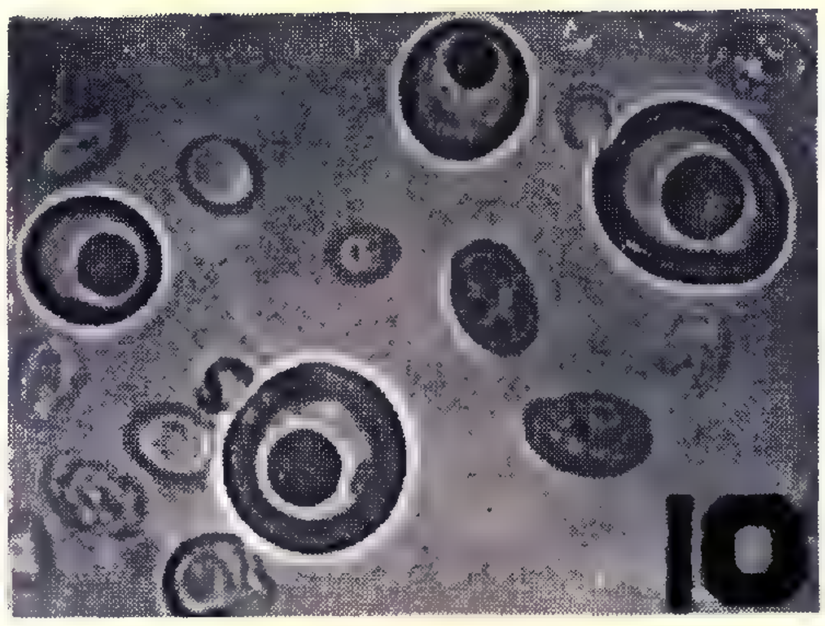
Fig. 14. *T. pulcherrima.* A large "pulcherrima cell" (11.2 μ in diameter) from a culture grown on peach leaf agar, showing an attached, intact, empty daughter cell. Unstained. (1200x).

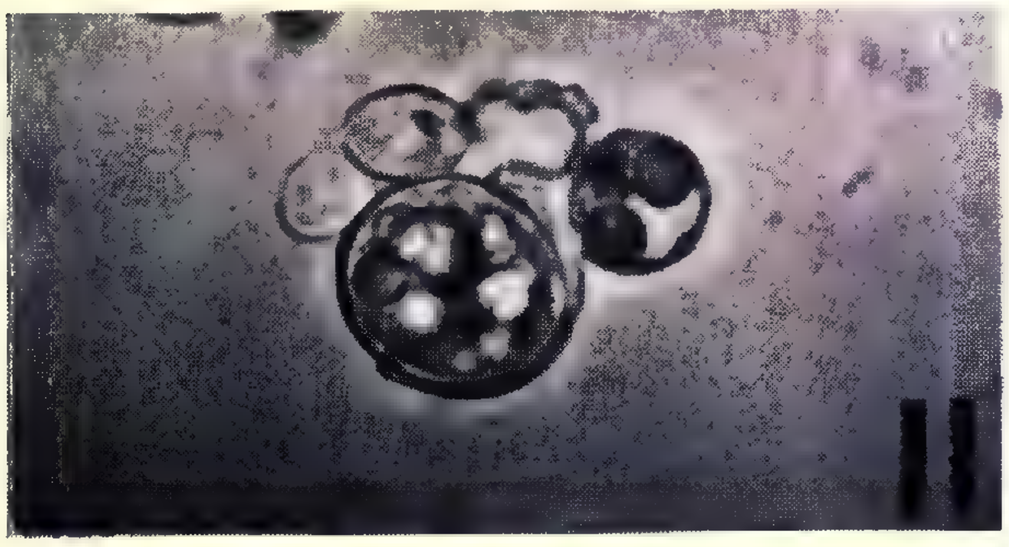


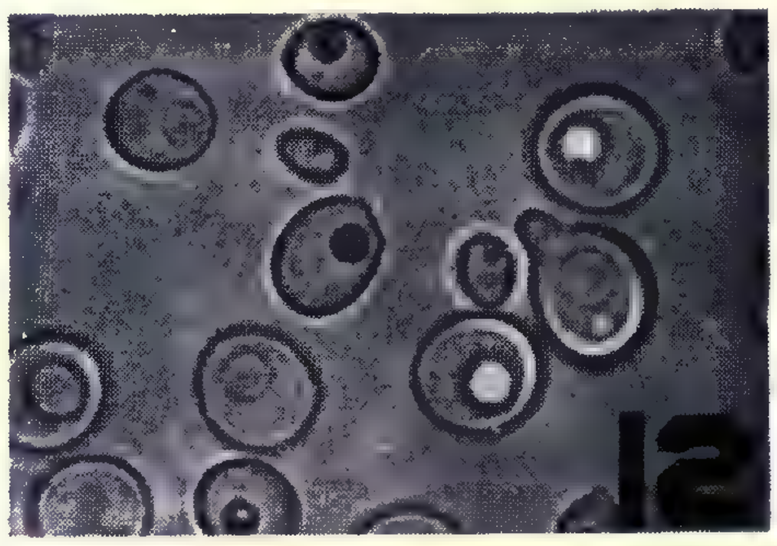












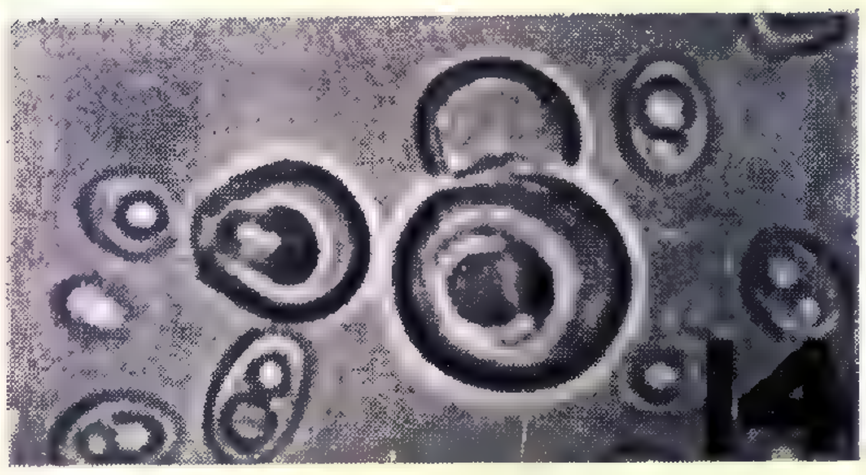


PLATE I

EXPLANATION OF PLATE II

Fig. 1. *T. pulcherrima.* A large "pulcherrima cell" from a pigmented, 2-month-old, single cell culture, showing an attached, intact, empty daughter cell. Unstained. (1200x).

Fig. 2. *T. pulcherrima.* A "pulcherrima cell" from a pigmented, 4-month-old, mass culture, showing an attached daughter cell containing one spore-like body. Note the single oil globules in the mother cell and in the spore-like body. Unstained. (1101x).

Fig. 3. *T. pulcherrima.* "Pulcherrima cells" from a pigmented, 3-month-old, mass culture, showing one cell which possesses an attached daughter cell containing two spore-like bodies. Unstained.

Fig. 4. *T. pulcherrima.* A "pulcherrima cell" with a single oil globule from a pigmented, 4-month-old, mass culture, showing the attached remnant of a daughter cell. Unstained. (1101x).

Fig. 5. *T. pulcherrima.* A "pulcherrima cell" with a single oil globule and the attached remnant of a daughter cell. From same culture noted in Fig. 4. Unstained. (1200x).

Fig. 6. *T. pulcherrima.* Growth after 24 hours from a single thick-walled cell with attached empty daughter cell, both of which had been withdrawn together from the margin of a colony. Note that only 2 cells were produced during this time. Unstained. (588x).

Fig. 7. *T. pulcherrima.* Cells from a non-pigmented, single cell colony which appear to show evidences of copulation. The long outgrowths may be regarded as conjugation tubes. Stained with cotton blue in lactophenol. (867x).

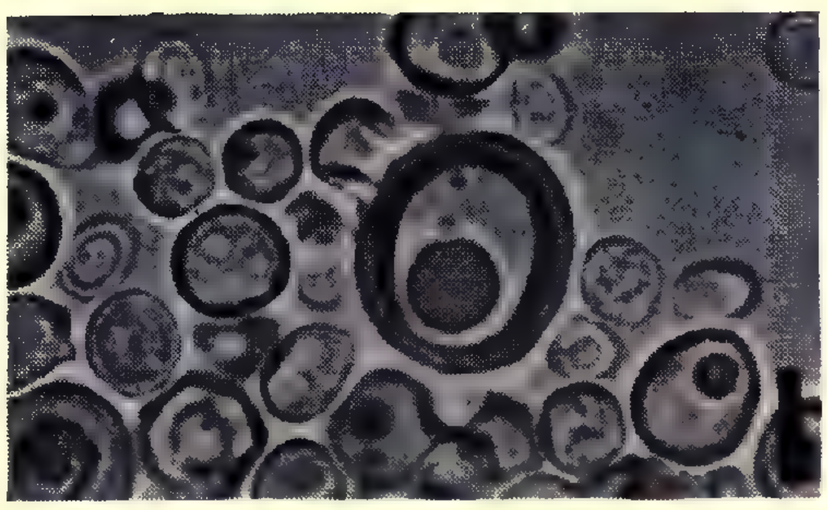
Fig. 8. *T. deformans.* Two large cells, one with many oil globules and a papillate protrusion, and the other with a single oil globule and an attached, intact, empty daughter cell. From a 4-month-old mass culture. Unstained. (1101x).

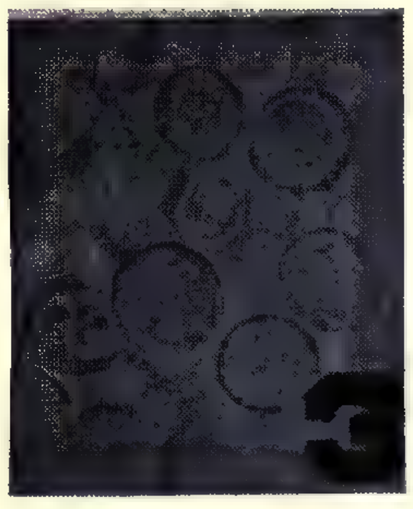
Fig. 9. *T. deformans.* Cell from a 6-month-old single spore culture, showing a thick-walled cell with an attached daughter cell containing a single oil globule (or perhaps a spore-like body). Unstained. (1101x).

Fig. 10. *T. deformans.* Large cell with attached daughter cell containing 2 spore-like bodies. Note oil globules within spore-like bodies. From same culture noted in Fig. 8. Unstained. (1101x).

Fig. 11. *T. pulcherrima.* Typical "pulcherrima cells" from a pigmented, month-old, single cell colony. Unstained. (1200x).

Fig. 12. *T. pulcherrima.* Thin-walled vegetative cells from a non-pigmented, 25-day-old, single cell colony. Unstained. (1200x).





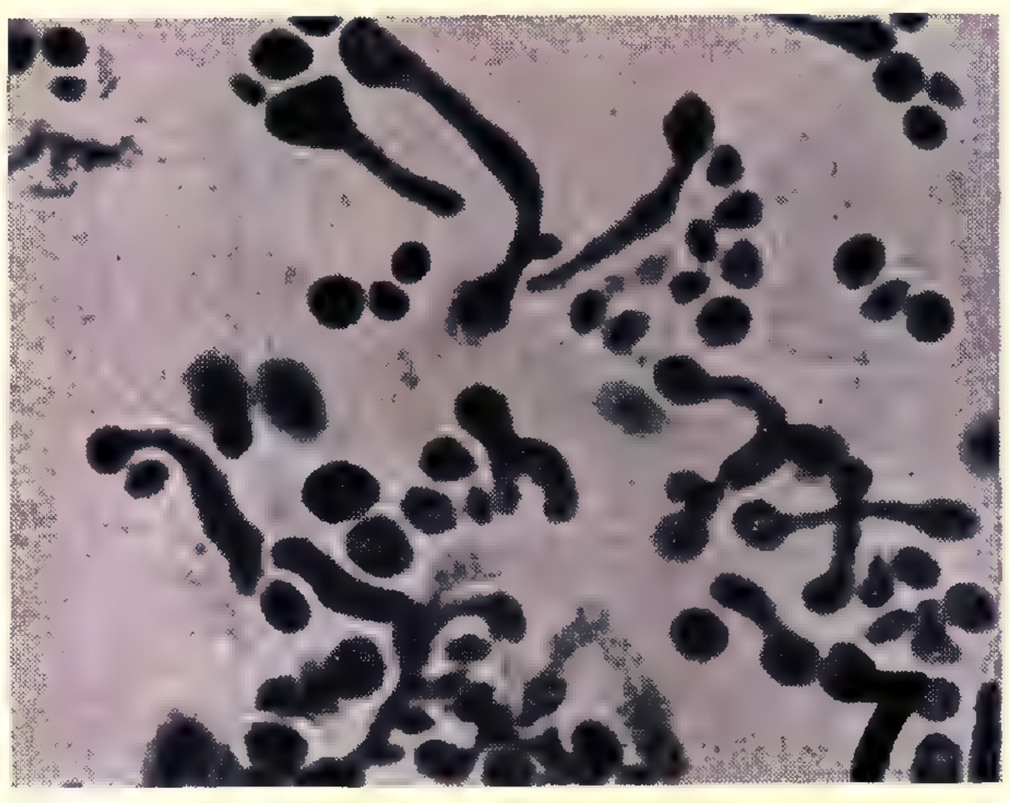
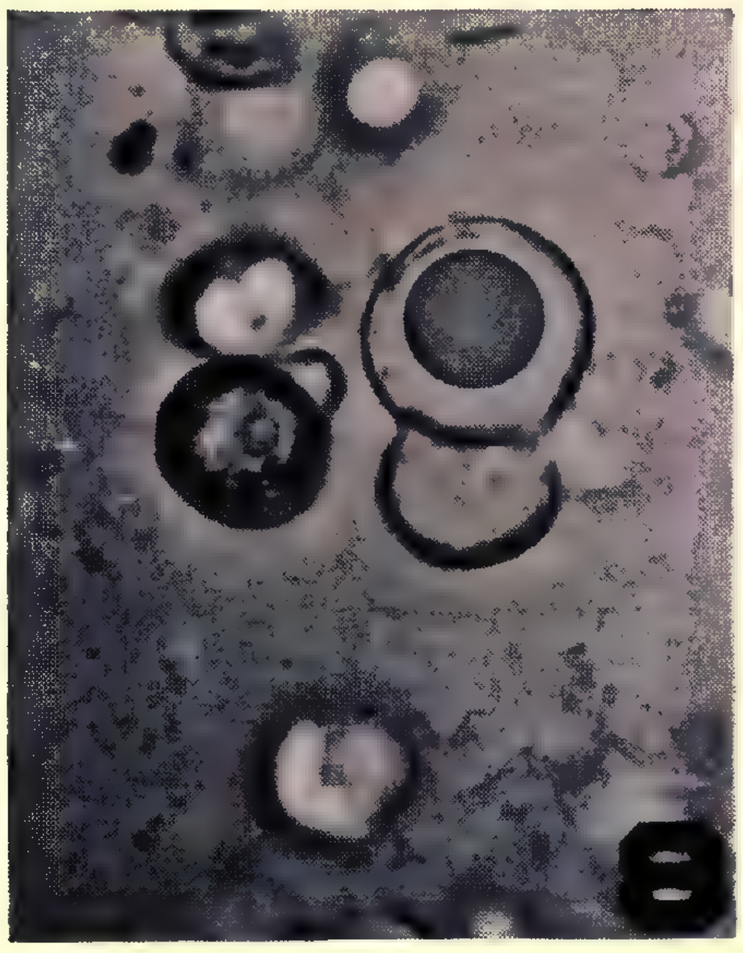
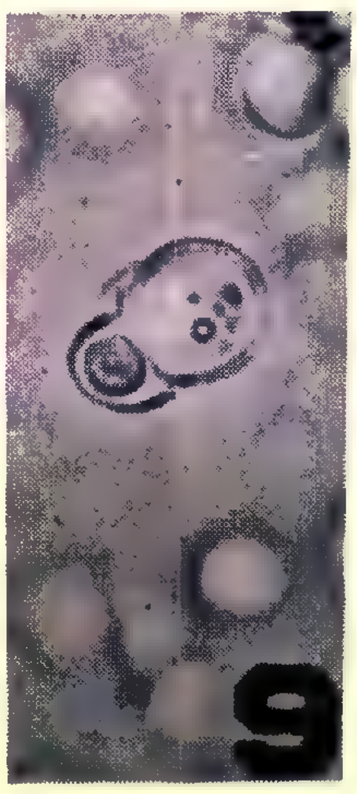
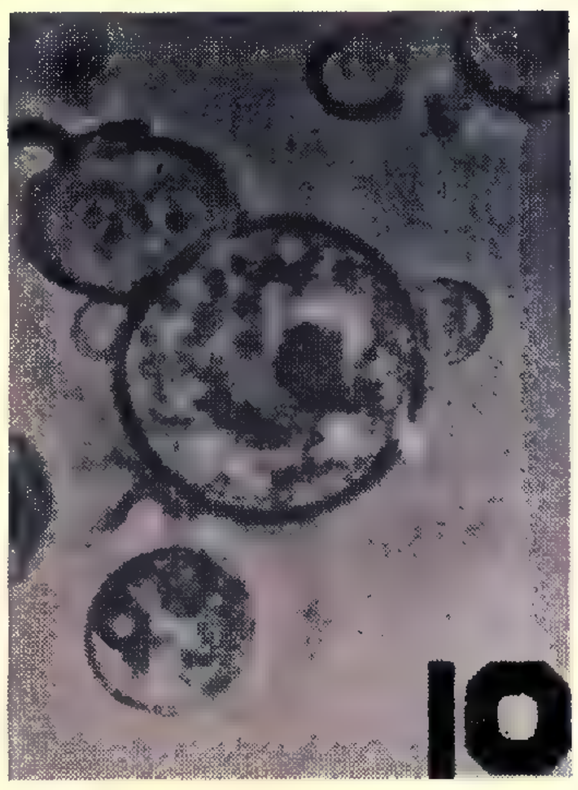
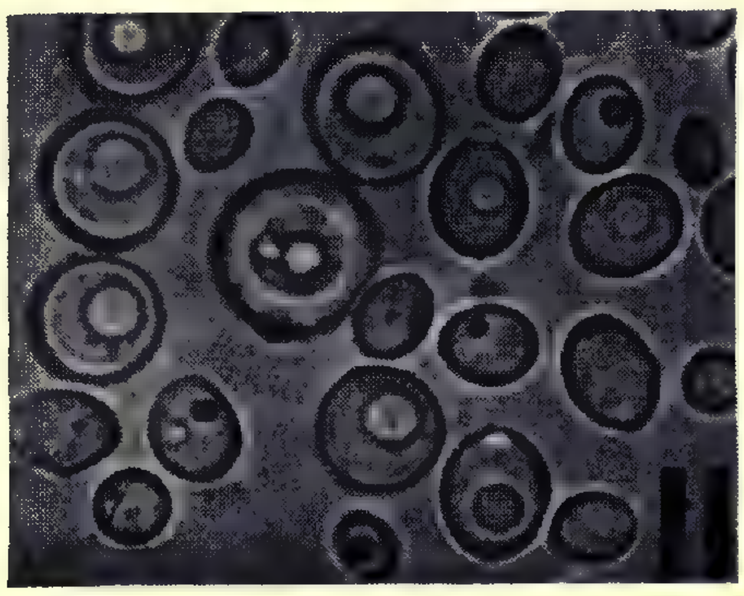
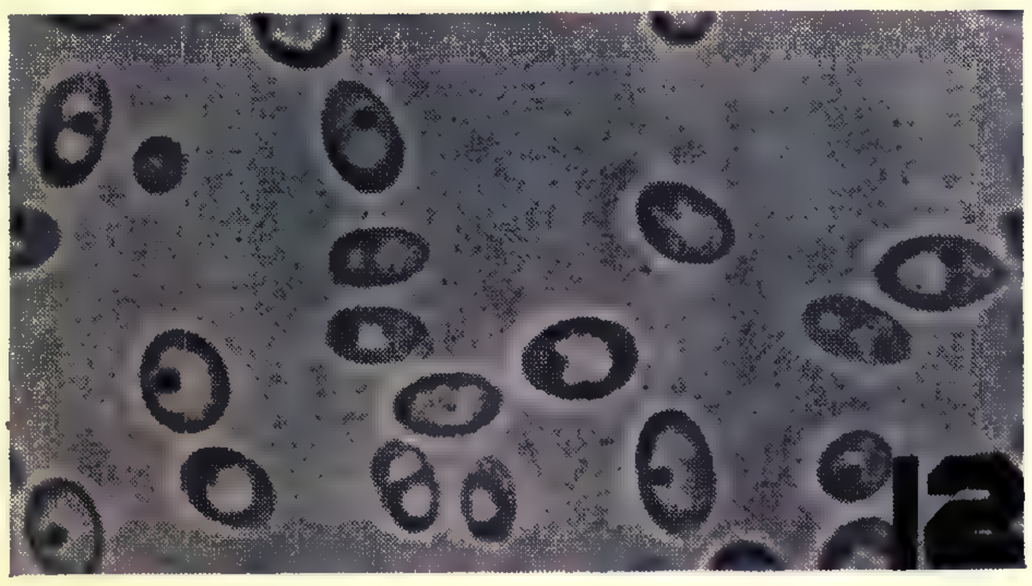







PLATE II

EXPLANATION OF PLATE III

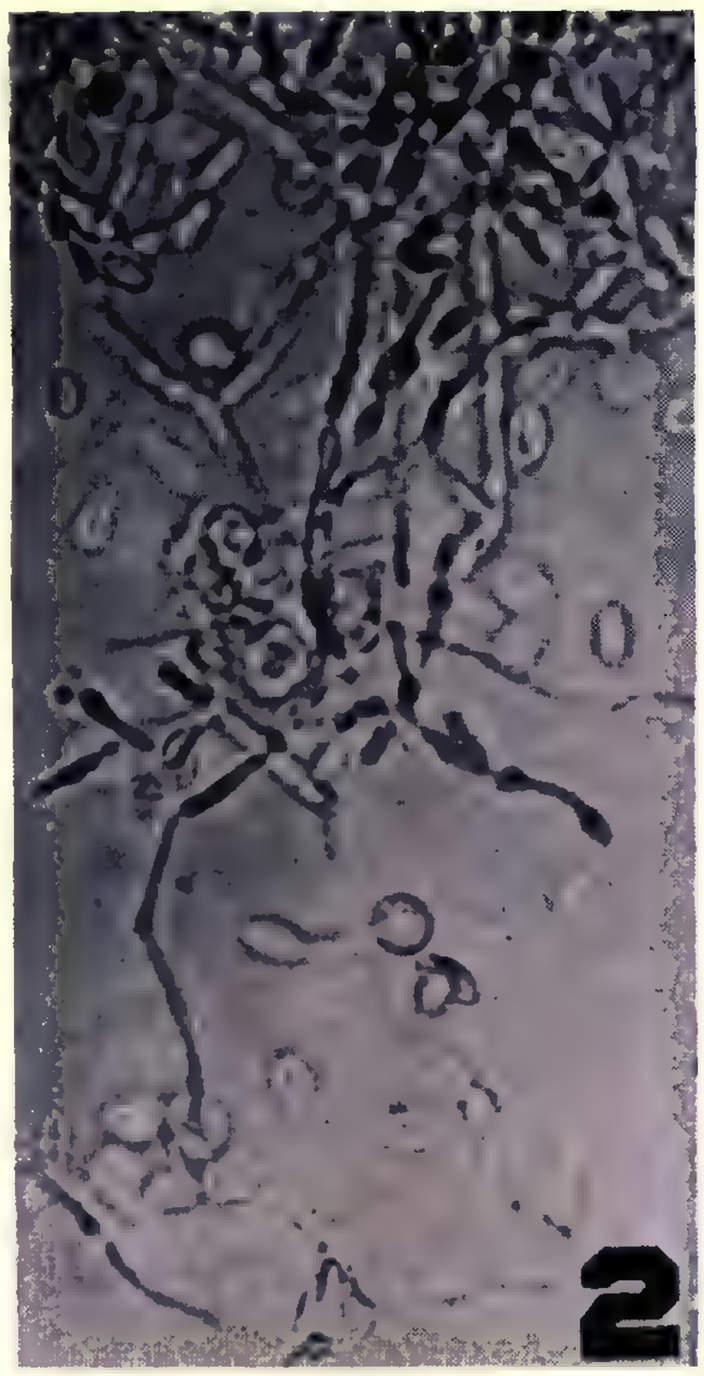
Fig. 1. *T. deformans*. Mycelial tendency occurring in a 2-month-old, single spore, smooth colony. Unstained. (588x).

Fig. 2. *T. deformans*. Mycelial tendency occurring in a rough sector of a 3-month-old, single cell colony. Stained with cotton blue in lactophenol. (588x).

Fig. 3. *T. pulcherrima*. Nuclear staining of cells from a 5-day-old, pigmented, mass culture. (1200x).

Fig. 4. *T. pulcherrima*. Nuclear staining of cells from a 5-day-old, non-pigmented, single cell culture. (1200x).

1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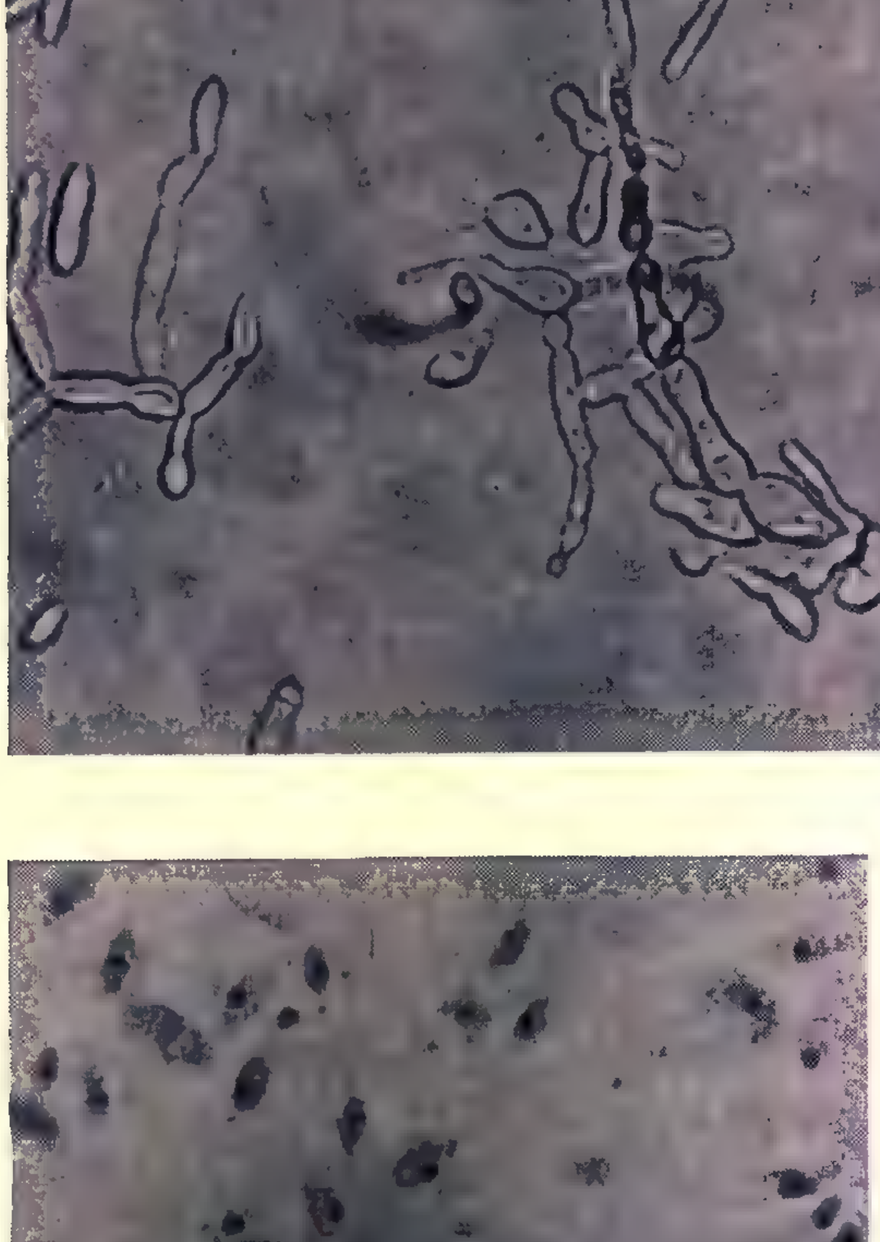
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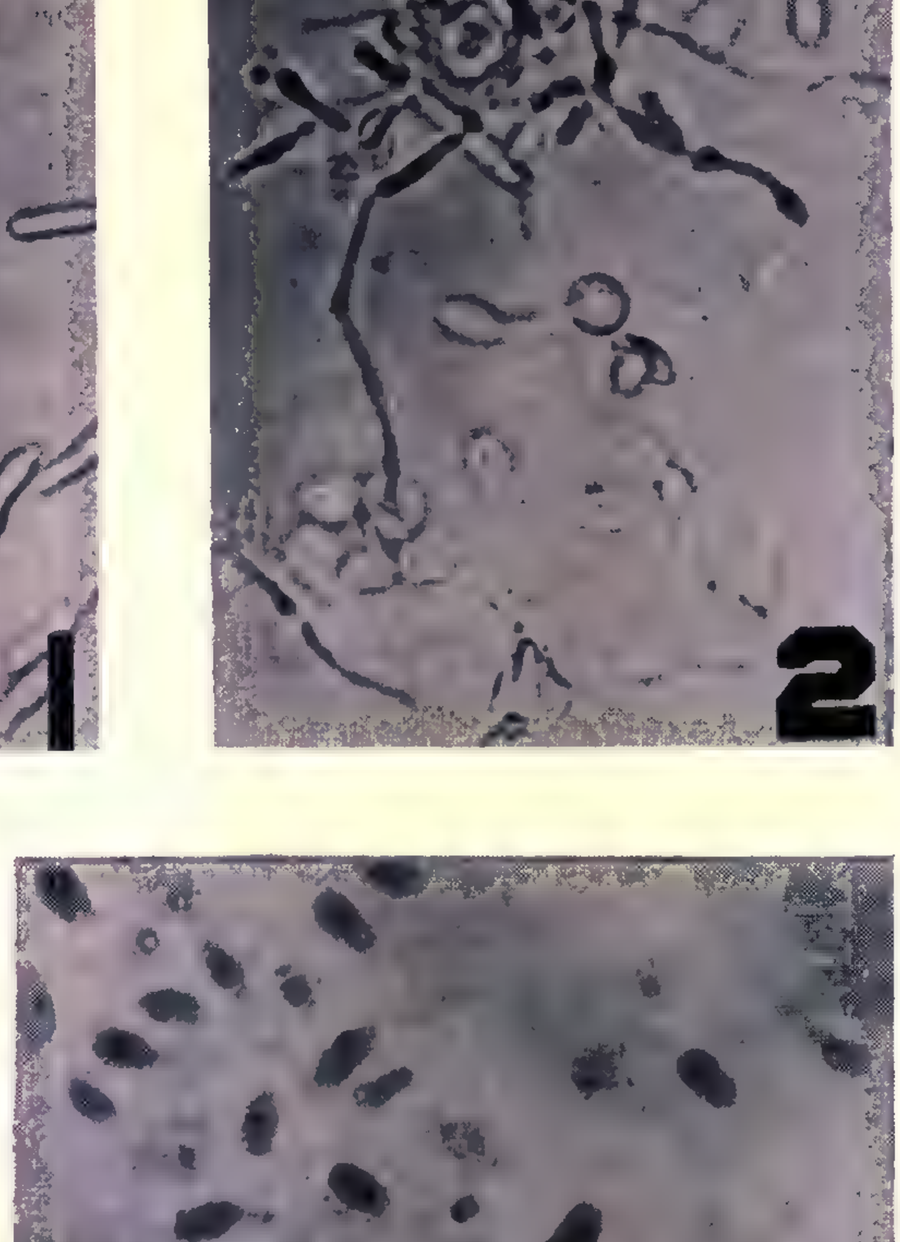
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PLATE III

2(3):385–437 FARLOWIA JANUARY, 1946

THE CYPERICOLOUS AND JUNCICOLOUS SPECIES OF SCLEROTINIA

H. H. WHETZEL [1]

During the spring and summer of 1930 I took the opportunity afforded by sabbatic leave to collect and study species of the *Sclerotiniaceae* in Europe. My travels carried me through England, Holland, Switzerland, France, Germany, Denmark, Sweden and Norway. Through the kind co-operation of colleagues [2] in these countries I was enabled to make invaluable collections and studies of many species in their natural habitat. I was also afforded every courtesy and assistance in the examination of specimens of these cup fungi preserved in the herbaria of most of the important botanical institutions in the countries visited.

Stimulated by my early studies on the species of *Sclerotinia* found in northeastern United States on species of *Carex* (Whetzel 1929) I took special pains to collect and study the species of this genus occurring on sedges and rushes in western Europe. I was exceptionally fortunate in finding in nature most such species recorded by European mycologists.

A manuscript presenting the results of my studies on these species was partially prepared during my stay in Europe. On my return, teaching duties prevented the completion of this paper, and only recently have I been able to take up the work again and complete the studies which are here presented. This delay has not been without its compensations in certain respects. During the years that have passed, while much of the freshness and some of the details of my European observations have faded

[1] This manuscript was received and edited before Professor Whetzel's death on November 30, 1944. Realizing that he might not live to see the appearance of his paper, the author made all arrangements for its publication, including a generous gift to cover the extra cost of the halftone plates.

[2] *Acknowledgments:* The researches on which this paper is based, especially those undertaken in Europe in 1930, were made possible largely by grants from the Heckscher Foundation for the Advancement of Research at Cornell University. I am especially indebted to Dr. Cynthia Westcott, who as my research assistant gave invaluable help on my European trip. For access to herbarium specimens and for expert advice and assistance I am greatly indebted to Drs. David H. Linder and W. L. White of the Farlow Herbarium; to Dr. John A. Stevenson of the U.S.D.A.; to Dr. W. G. Solheim of the University of Wyoming; to Dr. J. Ramsbottom of the British Museum; to Dr. A. D. Cotton and Miss E. M. Wakefield of the Royal Herbarium, Kew; to Dr. J. A. Nannfeldt, University of Upsala; and to Mr. Ernst Gram, Dr. C. Ferdinandsen, and Mr. Johs. Grøntved of the University of Copenhagen. My best thanks are also due Miss Charlotte Dill and Mr. Carlos Garcés for preparation of the drawings for the text figures and to Dr. Rolf Singer of the Farlow Herbarium who has kindly prepared the Latin descriptions. Mr. W. R. Fisher prepared the photographs. The writer is indebted to so many other friends and colleagues both in this country and in Europe for assistance and favors that it is useless to attempt to list them all here. To everyone who has thus contributed to the consummation of these investigations I here express my thanks and gratitude.

from my memory, there have come to hand, now and then, specimens and information on species of this group that have corrected some of my earlier conclusions, confirmed others, and have added three species to those known to me at the time of my 1930 visit in Europe.

THE GENUS SCLEROTINIA

The generic name, *Sclerotinia*, should be restricted to those species in which the apothecium arises from a tuberoid sclerotium as in *S. sclerotiorum* (Lib.) De Bary, which is to be taken as the type of the genus. In this genus the sclerotia originate and develop upon the surface of the substrate or in lysigenous cavities within the organs of the suscept. They rarely and only incidentally enclose in their pseudoparenchyma bits of the tissue of the suscept. The sclerotia when freely formed upon the surface of the substratum are approximately loaf-shaped or globose. Even those species which form characteristically shaped sclerotia regularly within the organs of their suscepts, when grown on artificial culture media produce sclerotia which tend to be globose in shape. None of them are true parasites. They must kill the cells of the invaded tissues before they are able to extract the nourishment they seek. They are necrogenic saprophytes. They have no conidial stage. All have spermatia (microconidia) produced endogenously from the tips of obclavate spermatophores, fasciculately massed into mucilaginous spermodochia, borne free on the aerial mycelium or enclosed in lysigenous cavities in the tissues of the suscept.

The species here discussed are the only ones known to me on sedges and rushes that may be properly referred to the genus *Sclerotinia* as above characterized. A number of species of Discomycetes, recorded on various species of these plants and referred to the genus *Sclerotinia*, do not qualify. These in so far as they are known to me are listed and briefly discussed at the end of this paper.

SPECIES TREATED IN THIS PAPER

As a stimulus to the reader to plunge into the details of my observations and conclusions on the species treated in this paper, it may be well to present here a list of these together with the sedges and rushes which they inhabit. There are ten species occurring on forty-one different suscepts. These species are largely restricted each to a distinct suscept or set of suscepts. Only among the four species on *Carex* have there been found a few cases of suscepts common to two or more.

On the Cyperaceae:

1. **Sclerotinia duriaeana** [3] (Tul.) Rehm in EUROPE only, on *Carex brizoides* [4] L.; *C. paniculata* L.; *C. disticha* Huds.; *C. chordorrhiza* Ehrh.;

[3] Exercising his option under the rules, the author decapitalizes the first letter of species names.

[4] The species names here used for the suscepts have been carefully checked by my colleague Dr. R. T. Clausen.

C. acutiformis Ehrh. 2. **Sclerotinia sulcata** (Desm.) Whetzel in EUROPE on *Carex hudsonii* A. Bennett; *C. vulpina* L.; *C. gracilis* Curtis; *C. inflata* Huds.; *C. brizoides* L.; *C. nigra* (L.) Reichard; *C. disticha* Huds.; *C. paradoxa* Willd.; *C. paniculata* L.; *C. riparia* Curtis, in NORTH AMERICA on *Carex stricta* Lam.; *C. prairea* Dewey; *C. interior* Bailey; *C. hystricina* Muhl.; *C. riparia* var. *lacustris* (Willd.) Küken; *C. flava* L.; *C. inflata* var. *utriculata* (Boott) Druce; *C. crinita* Lam.; *C. nebraskensis* Dewey. 3. **Sclerotinia longisclerotialis** Whetzel in NORTH AMERICA only, on *Carex prairea* Dewey; *C. interior* Bailey; *C. vesicaria* L.; *C. crinita* Lam.; *C. retrorsa* Schw.; *C. oligosperma* Michx. 4. **Sclerotinia caricis-ampullaceae** Nyberg in EUROPE and NORTH AMERICA on *Carex aquatilis* Wahl.; *C. aquatilis* var. *altior* (Rydb.) Fern.; *C. inflata* Huds. 5. **Sclerotinia vahliana** Rostr. in EUROPE and NORTH AMERICA on *Eriophorum scheuchzeri* Hoppe; *E. angustifolium* Roth.; *E. vaginatum* L. 6. **Sclerotinia scirpicola** Rehm in EUROPE only, on *Scirpus lacustris* L. 7. **Sclerotinia schoenicola** n.sp. in EUROPE only, on *Schoenus nigricans* L.

On the Juncaceae:

8. **Sclerotinia curreyana** (Berk. *in* Currey) Karst. in EUROPE only, on *Juncus effusus* L.; *J. conglomeratus* L.; *J. glaucus* Ehrh.; *J. filiformis* L.; *J. communis* E. Mey. 9. **Sclerotinia juncigena** (E. & E.) n.comb. in NORTH AMERICA only, on *Juncus effusus* L. var. *pacificus* (Fern.) Wieg. 10. **Sclerotinia luzulae** n.sp. in EUROPE only, on *Luzula pilosa* Willd.

LIFE HISTORY

The life histories of the *Sclerotinia* species attacking sedges and rushes are in their main features very much alike. The discharged ascospores, carried by air currents, fall upon the flowers of their suscepts. Germination and invasion of the flowers is followed promptly by death and browning of the entire inflorescence, the affected culms never setting seed. The invading hyphae now work rather slowly down the culm forming spermodochidia [5] (Text Figs. A, C, D) in the cortical tissues just beneath the epidermis. The increasing mass of spermatia in these fruit bodies soon burst through the epidermis in pearly white or brownish mucilaginous drops. Rain or dew and possibly insects disseminate the spermatia to the surfaces of the dying culms below wherein the sclerotia are now beginning to develop. The mechanism of fertilization is unknown but that the spermatia do function is certain. The sclerotia, at first evident as white soft cottony masses within the culm, gradually harden, enveloping the medulla in a thin black rind. This medulla is often pink at first, eventually becoming white. In the final stages of maturity in late autumn, the sclerotia usually burst the confining outer tissues of the culm. In some species they fall out of the culms onto the water or moss beneath. In other species they remain partially enclosed,

[5] For a definition of this term see Whetzel, Mycologia **35:** 335–338. 1943.

exposing only a part of their surface. In one species, *S. longisclerotialis* (Fig. 20), the sclerotia remain enclosed until decay of the culm tissues more or less frees them the following spring. The natural shape of the sclerotium is usually characteristic for each species, but is evidently determined to some extent by the shape of the enveloping culm. The number of sclerotia per culm varies not only with the species of *Sclerotinia* but to some extent, and within limits, in most of the species of their respective suscepts.

The sclerotia of those species in which they are freed at maturity, float on the surface of the water, eventually finding lodgment among the mass of debris about the hummocks or shores of the swamp. In some species the sclerotia remain upright in the dead culms throughout the winter. In *S. longisclerotialis* the dead slender culms enclosing the sclerotia fall over and settle to the bottom of the pools about the hummocks.

Development and maturity of the apothecia of all the species are closely correlated with the growth and flowering of their respective suscepts early in the spring. The ascospores are matured and discharged over a period of two weeks or so while the flowers of their suscepts are opening and shedding their pollen. Thus for the species of *Sclerotinia* attacking sedges and rushes there is a single primary cycle of activities. So far as known, secondary cycles do not occur. Each species presents certain peculiarities and variations from the life-history picture outlined above. These will be pointed out in connection with the discussion of the different species. This outline of their life history is inferred largely from observations on their seasonal developments and the syndrome of the diseases they cause. Most of them have been grown on potato dextrose agar. Much remains to be discovered by further field studies and especially by carefully executed inoculation experiments. Several of them, no doubt, have a more extensive suscept range than my observations indicate. They appear to have been very infrequently collected, not only in North America but also in Europe. Considering their abundance and annual reappearance in the localities where I have had them under observation, it is surprising how scanty in numbers and quantities are the specimens in the herbaria which I have visited.

SPECIES ON THE CYPERACEAE

Of the seven species of *Sclerotinia* known to me to attack members of the *Cyperaceae*, four occur on species of *Carex*, one on *Scirpus*, one on *Eriophorum*, and one on *Schoenus*. These appear to constitute a group of very closely related species. All occur in much the same type of environment, namely in wet marshes where water stands throughout the year or along the margins of lakes, ponds, and quiet streams. They appear to be restricted to the cooler parts of the north temperate zone and on up into the colder arctic regions. They usually occur in great abundance in the localities where I have found them both in America and Europe.

SPECIES ON CAREX

Four species of *Sclerotinia* pathogenic to *Carex* species have been described. Of these *S. duriaeana* (Tul.) Rehm is known only from northwestern Europe, occurring widely on several species of *Carex* from France northward to Lapland in Scandinavia; *S. sulcata* (Desm.) Whetzel occurs in both Europe and America. It appears to be generally distributed over western Europe from south to north wherever its *Carex* suscepts occur. It is this species which has been most frequently collected and preserved in European herbaria but almost always erroneously labeled *Sclerotinia duriaeana*, with which it has generally been confused by European mycologists. While *S. longisclerotialis* Whetzel infects many species of *Carex* in northeastern United States it apparently does not occur in Europe. The fourth species, *S. caricis-ampullaceae* Nyberg, discovered in Finland in 1930 and first described two years later, has been collected since in Sweden as well as in North America in the high mountain swamps of Wyoming (Whetzel and Solheim 1943). This is the largest and most striking of the four species (Fig. 25). The apothecia of these four species differ chiefly in size and somewhat in shape. The differences in color of the apothecia and in the shape and size of asci and ascospores are scarcely of taxonomic significance. The species are most clearly distinguishable by the shape and size of their sclerotia together with the external appearance and arrangement of their spermodochidia.

KEY TO THE SPECIES

1. Sclerotia short, more or less fusiform, falcate or kidney-shaped.
   2. Spermodochidia in globose, equally spaced groups..... **S. duriaeana**
   2. Spermodochidia in linear, scattered groups..... **S. sulcata**
1. Sclerotia long and slender.
   3. Sclerotia of uniform diameter, truncate, more or less 3-angled **S. longisclerotialis**
   3. Sclerotia obclavate, drawn out above into a slender whiplike tip **S. caricis-ampullaceae**

SCLEROTINIA DURIAEANA

PLATE I & II

A clear and accurate concept of this species has long been beclouded by errors in identification of certain stages in its development and by its frequent confusion with *S. sulcata* (Desm.) Whet. by mycologists subsequent to its description by Tulasne in 1861. I have already presented (Whetzel 1929) in some detail the basic evidence for this confusion of the two species. Critical examination of specimens preserved in European herbaria together with observations in the field, in culture, and on preserved specimens of both these species personally collected on numerous species of *Carex* in Europe during 1930, has fully confirmed my earlier provisional conclusion (Whetzel 1929: 15) that the two species have commonly been confused under the name *Sclerotinia duriaeana*.

While I made numerous collections of the spermatial and sclerotial stages of this species in most of the countries visited, I was in most places too late

PLATE I

to find apothecia. Unfortunately I was unable to visit the type locality where Durieu made his collections and observations on this species. I did, however, make two collections of apothecia which appear to be those of *S. duriaeana*, one near Rambouillet, France, (CUPP *31561*) and another near Lyngby, Denmark, (CUPP *31564*) (see data and comments below p. 395). In neither case were many apothecia found and the circumstances under which they were taken raises some question as to their identity. Perhaps if I had found abundant fresh cups of both species, each of unquestionable identity, I might have detected some differences of specific significance in their apothecia. I doubt it. Such evidence as is available offers little expectation that they are thus distinguishable. The sclerotia of the two species cannot with confidence be told apart and the spermatial stages alone provide ready and certain identification. (Compare Figs. 1 and 13.) A more extensive comparison than I have been able to make of these two species in artificial pure culture would almost certainly also provide dependable evidence for distinguishing between them.

In view of the scattered, confused and incomplete published data and descriptions of *S. duriaeana*, it appears desirable to present here a more complete and accurate description of the species, interpreted in the light of my own studies and observations.

SCLEROTINIA DURIAEANA (Tul.) Rehm, Hedwigia **21:** 66. 1882.

Epidocium ambiens Desm. Ann. Sci. Nat. Ser. 3, **20:** 231. 1853.
Peziza duriaeana Tul. Sel. Fung. Carp. **1:** 103. 1861, and **3:** 203, *pl. 22, fig. 20–24.* 1865.
Sphacelia nigricans sensu Sacc. Michelia **2:** 131. 1880.
Sclerotium nigricans sensu Sacc. Michelia **2:** 134. 1880.
Sphacelia ambiens Sacc. Syll. Fung. **4:** 666. 1886.
Sclerotinia duriaeana Sacc. Syll. Fung. **8:** 199. 1889.
Sclerotinia duriaeana (Tul.) Quélet (In error. See Notes p. 395.)
Hymenoscypha duriaeana Phill. Manual Brit. Discom. p. 115. 1893.
Myrioconium ambiens V. Höhnel. Mitt. Bot. Inst. Tech. Hochsch. Wien. **3:** 50. 1926.

Spermodochidia (Figs. 1, 3 & 7) dull black in paired groups of 3–6 at regular intervals of 5–15 mm. along upper part of culm, 5–15 paired groups per culm, groups oblong to subglobose when moist, 1–3 mm. long, arranged parallel side by side lengthwise of the culm, usually on but two sides of the 3-angled culm, sometimes encircling the culm as in *C. chordorrhiza* (Fig. 2); at maturity becoming swollen and rupturing the culm, discharging the viscid, olivaceous mass of spermatia; *spermatia* minute, globose, 2–3 μ in diam., faintly olivaceous.

The spermodochidia are formed in lysigenous cavities in the palisade parenchyma of the culm, between the vascular bundles. Each spermo-

Plate 1. *Sclerotinia duriaeana.* **Fig. 1.** (Left) diseased heads of *Carex paniculata* L.; (right) healthy head, with spermodochidia and sclerotia in the diseased culms. CUPP *31562.* **Fig. 2.** Diseased culms of *C. chordorrhiza* Ehrh. showing the spermodochidia. CUPP *31563.* **Fig. 3.** Culm of *C. paniculata* with spermodochidia and sclerotium from De Thümen's Myc. Univ. *1557.* All figures natural size.

Peziza Durieuana Tul.
Sclerotia et Epidochium
m. Dieu 8 et 9 fév. 1861
Peziza Durieuana
Tul.
in agro Burdigalensi
ulieu de M.
1856
Première phase, à l'état d'ergot
caulinaire, sur le chaume du
Carex arenaria (Langon, 1er juillet 1855)
Ergot planté le 20-9bre 1855
Etat parfait recueilli le 15 avril 1856 HBR
feuille d'herb.
4
5
6
7

PLATE II

dochidium contains many spermodochia surrounded by masses of spermatia. (See Tulasne 1865: *pl. 22, fig. 21.*)

Sclerotia (Fig. 4) one to several in each culm, from which they are discharged at maturity through a slit in the culm over the sclerotium by the toppling of the upper part of the culm which bending at this point opens the sclerotial cavity; black, slender, fusiform, more or less curved when dry, when fresh plump, fusoid, slightly 3-angled, varying in length and thickness according to the size of the culm in which formed, 5–15 mm. long. The sclerotia first appear within the culm as elongate, pink, cottony masses of hyphae, which gradually darken externally as the dull black rind is formed and the densely packed thick-walled hyphae of the white medulla takes form.

Apothecia variable in size, depending upon the size of the sclerotia from which they arise, usually but one from each sclerotium; *cup*, 5–10 mm. in diam. occasionally larger, shrinking greatly on drying, deep goblet-shaped, thin, fragile, light fawn to vinaceous brown, lighter beneath due to a fine hyphal fuzz which covers the under surface when fresh; *stipe* rather short, its length usually about the diameter of the fully open cup, nearly or quite smooth; *asci*, according to Tulasne (1861: 106) are "8-spored (spores obliquely and closely uniseriate, seldom biseriate), cylindrical, obtuse, straight, 8–9.5 μ wide and about ten times as long." Boudier (1910: 274) describes them as cylindrical, rather large, slightly attenuate toward the base, 8-spored, pore blue with iodine, 210–230 x 7–10 μ; *ascospores* are described by Tulasne (*l.c.*) as "ovate, inequilateral, obtuse at both ends and muticous, smooth, unilocular, and filled with oil the greater part measuring 10–15 x 6.5–7.5 μ, but some not exceeding 8–9.5 x 5 μ." Boudier describes them as oblong-fusiform, colorless, usually without internal granules, but sometimes cloudy or rarely with non-oily droplets, 14–18 x 6–7 μ. Tulasne (1865: *pl. 22, fig. 24*) describes the discharge of the ascospores and their germination which he illustrates showing the direct formation on them of spermatophores and spermatia; *paraphyses* slender, slightly thickened at the tips, hyaline, sparingly septate, vacuolate (Boudier 1907: *pl. 473, fig. 9*; 1910: 274).

HABITAT: In culms of *Carex* species, growing in open swamps, marshes and wet meadows in western Europe.

TYPE SPECIMENS: Collected by Durieu de Maisonneuve in culms of *Carex brizoides* L. during the years 1855 to 1861 in the sandy meadows along the river Ciron about the ruins of the Château de Fargues not far from the towns of Langon and Bazas, France. There appears to be no

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Plate 2. *Sclerotinia duriaeana.* **Fig. 4.** Photograph of Durieu's type specimens of the apothecium and sclerotia deposited in the Botanical Museum, Paris, sent me by Roger Heim; natural size. Tulasne (Sel. Fung. Carp. **3:** pl. 22, fig. 23) presents a good sketch of the apothecium of this species. **Fig. 5.** Mycelial growth from bits of diseased culms of *C. paniculata* on potato dextrose agar; ½ natural size. CUPP *31562*. **Fig. 6.** Mycelium and spermodochidial masses from tissue plantings from culms of *C. chordorrhiza* on potato dextrose agar; ½ natural size. CUPP *31563*. **Fig. 7.** Spermodochidia on culm of *C. chordorrhiza*, x6. CUPP *31563*.

evidence that Tulasne preserved specimens of the materials on which his description of the species was based. The specimens he had in hand appear to have all been sent him by Durieu. Durieu, however, preserved what are obviously duplicate specimens of those sent Tulasne. These specimens were later, 1878, deposited in the cryptogamic herbarium of the Museum of Natural History in Paris (Fig. 4). These specimens therefore may be properly considered the type specimens of this species. These, together with rather extensive notes in Durieu's handwriting, were in 1930 mounted on herbarium sheets. Photographic copies of three of these sheets were kindly sent me by the curator, Dr. Roger Heim, after my visit to the museum. These are on file with my notes on this species. Duplicate specimens of sclerotia and infected inflorescences bearing spermodochidia from Durieu's collection of June 24 and 26, 1860, are filed in CUPP *17044*. I found among Durieu's specimens but one apothecium (Fig. 4), apparently one of those developed from his first collection of sclerotia, July 1, 1855.

Since no species of *Carex* other than *C. brizoides* was found in Durieu's collections, and since this is the species pictured by Tulasne, it would appear that neither of them had in hand specimens of *S. sulcata* which they might have confused with *S. duriaeana*. Tulasne's (1861: 103) application of the name *Sclerotium sulcatum* Roberge *in* Desmaz. to the sclerotial stage of *S. duriaeana* was at the time a pardonable error. The only other name of the sclerotial stage of this species which has been applied is *Sclerotium nigricans* Sacc. given it by Saccardo (1880: 134, and 1899: 1153) under the erroneous impression, however, that the specimens in hand were sclerotia of *Claviceps nigricans* Tul.

DISTRIBUTION: This species is known to occur only in Europe. It has not been found in North America. Apothecia apparently appearing in May, spermodochidia June to July, sclerotia July and August. It is known to me from France, Belgium, Germany, England, Denmark and Norway.

ILLUSTRATIONS: Tulasne, Sel. Fung. Carp. **3,** *pl. 22, fig. 20–24.* 1865. Boudier, Icon. Myc. **3:** *pl. 473.* 1907.

MATERIAL EXAMINED: On **Carex brizoides** L. (*C. arenaria* in error): (1) Durieu's type specimens deposited in the Crypt. Herb. Mus. Nat. Hist., Paris (fully discussed above). I also found what appear to be duplicate specimens (spermodochidia and sclerotia) from Durieu's collections in the Kew Herbarium labeled "*Peziza Duriaeana* on *Carex arenaria*" from Cooke's herbarium; — (2) Krieger, Fung. Sax. *1682*, "am grossen Winterberg," Germany, August 1, 1898 (spermodochidia and sclerotia). On **Carex paniculata** L.: Desmazières, Pl. Crypt. France. Ser. II, **20,** "Epidocium ambiens Desm. Not. XXI. En été, sur les tiges sèches de divers Carex, à Ouystreham par M. Roberge." France (spermodochidia only); — De Thümen, Mycotheca Univ. *1575*, "Epidocium ambiens Desm. f. Caricis paniculatae. Gallia. Grande Chartreuse pr. Grenoble. Aug. 1879, J. Therry." (spermodochidia and sclerotia); Roumeguère, Fungi Sel. *4682* "Sphacelia ambiens (Desm.) Sacc." (spermodochidia only); his Fungi Gallici *1200*, "Sclerotium nigricans (Tul.) Sacc." (spermodochidia) all appear to have been made up from one and the same original collection by Therry; — Roumeguère, Fungi Gallici *3505*, "Epidocium affine Desm. 3N.21. Chaumes du Carex paniculata. Tremonde (Belgique). Reliq. Westendorp." This is incorrectly determined. It is typical *Epidocium ambiens* Desm. The spermodochidia (no sclerotia) are typical of those of *S. duriaeana.* No date of collection is given; — Roumeguère, Fungi Sel. *4600*, "Sclerotium sulcatum

Rob. A l'interieur des chaumes secs du Carex paniculata. Louette Saint Pierre (Belgique). legit Aubert." (sclerotia only). No date given; — CUPP *31561*, swamp near Rambouillet, France, May 6, 1930, *Whetzel, Westcott & Duffrenoy*. Several apothecia found lodged on hummocks of *Carex paniculata* standing in a pool of water. It is barely possible that some of these apothecia are those of *S. sulcata*. Ascospores discharged from two of them (Figs. 5, 6) gave, however, cultures quite different from cultures of *S. sulcata* (Figs. 17, 18) and like those from infected culms of the following collection; — CUPP *31562*, swamp in outskirts of Faaborg, Isle of Fyn., Denmark, June 27, 1930, *Whetzel & E. Gram* (spermodochidia and sclerotia). On **Carex disticha** Huds.: Roumeguère, Fungi Selecti. Exs. *5419*, "Sclerotinia Duriaeana Tul. (conidies). Sur les chaumes maladifs d'un Carex sp. King's Lynn (Angleterre), Automne 1889." Coll. Plowright (sclerotia and spermodochidia). A. J. Wilmott of the British Museum says the *Carex* is *C. disticha* Huds.; — Phillips Herbarium, Brit. Mus., three collections on one sheet. One is labeled "Peziza Duriaeana Tul. King's Lynn. July 1888," presumably collected by Plowright, showing typical spermodochidia. A. J. Wilmott identified the suscept as *Carex disticha* Huds. Two others are sclerotia which bear apothecia, labeled respectively: "Peziza Duriaeana Tul., growing from sclerotia gathered June 3, 1883 by C. B. Plowright, King's Lynn"; and "Peziza Duriaeana Tul. cultivated from sclerotia on *Carex arenaria* by C. B. Plowright, June 1, 1883." Dupl. in CUPP *33271*. On **Carex chordorrhiza** Ehrh.: Flora Suecica, *1636*, under the name *Myrioconium ambiens* (Desm.), the spermatial stage only. Collected by J. A. Nannfeldt in Torne Lappmark, Jukkäsjarvi, at Abisko above the railway station August 9, 1928. Dupl. in CUPP *31620*. Apparently the first collection on this suscept; — CUPP *31563*, marshy bogs near hotel at Fjellsäter above Trondhjem, Norway. July 8, 1930, *Whetzel & Jørstad* (spermodochidia and sclerotia). On **Carex acutiformis** Ehrh. (?) (new suscept): CUPP *31564*, along the shore of Lyngby Sö, Lyngby, Denmark. June 5 and June 17, 1930, *H. H. Whetzel* (apothecia and sclerotia). The determination of the suscept by Grøntved of the University of Copenhagen is in some doubt as the single culm enclosing sclerotia is old and rotten.

In making the transfer of this species to the genus *Sclerotinia*, Rehm had before him (his Ascomyceten *603*) specimens of *S. sulcata* which he mistakenly took to be those of Tulasne's species *Peziza duriaeana* (Whetzel 1929: 7).

The combination, *Sclerotinia duriaeana* (Tul.) Quél. appears to be a strange error, originally made by Rehm in his "Discomyceten" *in* Rabenh. Krypt. Flora **1**[3]: 820. 1893. He here lists this species as "*Scl. Duriaeana* (Tul)" giving as a synonym, "Sclerotinia Duriaeana Quél. Bull. soc. myc. I. pag. 115". An examination of this reference discloses that the paper is by Boudier (not Quélet) in which he merely lists "*P*[*eziza*] *Duriaeana* Tul." as an example of species to be included in *Sclerotinia* Fckl. which Boúdier makes a sub-genus of *Ciboria* Fckl. Later Boudier in his Icones Myc. **4:** 274 writes "*Sclerotinia Duriaeana* (Tul.) Quél." without citing the place where Quélet is assumed to have made the transfer. Succeeding authors appear to have perpetuated the error.

Massee (1895: 283) cites as a synonym of *Sclerotinia duriaeana*, "*Epidocium arabicus* Desmaz. xxii. Not. in Ann. Sci. Nat., p. 19." This species name appears to be a strange error in the spelling of the name "*ambiens*." The reference he gives is obviously that of the original place of publication of *Epidocium ambiens*, the page being apparently that of a reprint instead of the original.

The names *Sphacelia nigricans* and *Sclerotium nigricans* were erected by

Saccardo who erroneously believed the sclerotia and spermodochidia in specimens (of *S. duriaeana*) on *Carex paniculata* were the sclerotia and spermoidea of *Claviceps nigricans* Tul. (Whetzel 1929: 9–10 and 1944: 426–428).

Von Höhnel (1926a: 50–51) erroneously lists *Epidocium affine* Desm. as synonymous with his *Myrioconium ambiens*, believing it to be the same as or a variety of *Epidocium ambiens* of Desmazières.

There is considerable variation in the measurements of asci and ascospores of *S. duriaeana* as recorded by different authors. I have made measurements of asci and ascospores from three collections of apothecia with the following results: (1) Plowright's collection on *C. paniculata:* asci (6 meas.) 121.2–151.5 x 6–9.5 μ; spores (50 meas.) 9.9–18.4 x 4.6–6.6 μ, mode 12.5 x 5.3 μ, av. 12.7 x 5.4 μ. (2) Whetzel's collection on *C. paniculata* (CUPP, *31561*): asci (30 meas.) 133.3–181.8 x 8.1–10.8 μ, mode 157.5 x 8.1 μ, av. 158.9 x 8.3 μ; spores (50 meas.) 10.5–14.5 x 4.6–7.2 μ, mode 11.8 x 5.3 μ, av. 11.9 x 5.4 μ. (3) Whetzel's collection on *C. acutiformis* (CUPP, *31564*): asci (40 meas.) 127.2–169.6 x 8.1–9.5 μ, mode 151.5 x 8.1 μ, av. 147.6 x 8.7 μ; spores (80 meas.) 9.9–15.8 x 5.3–7.9 μ, mode 13.2 x 6.6 μ, av. 13.3 x 6.5 μ. These measurements are distinctly smaller than those given by Boudier, but compare favorably with those given by Tulasne.

Although I cite Boudier's description and illustrations which he presents under the name *S. duriaeana*, I do so with some reservations. He does not specify the species of *Carex* on which his specimens occurred. His illustrations might just as well be those of *S. sulcata*. His measurements for asci and ascospores are rather large in comparison with the measurements of asci and spores of *S. duriaeana*. They more nearly approximate the maximum measurements of these structures in *S. sulcata*.

Whoever was responsible (presumably Durieu) for the identification of the *Carex* harboring the *Peziza duriaeana* which Tulasne had in hand, appears to have been in error. Culms from these collections bearing the typical spermodochidia and sclerotia as pictured by Tulasne (1865: *pl. 22, fig. 20*) have been critically examined by competent European taxonomists and declared to be *Carex brizoides* L., not *C. arenaria* L.

It is to be noted that of the *Carex* species on which *S. duriaeana* is known to occur only two are reported from North America. This may account for its apparent absence from the Western Hemisphere. It would appear to be most common and widely occurring on *Carex paniculata* and may yet be found on this suscept where that occurs in the Western Hemisphere.

SCLEROTINIA SULCATA

PLATES III AND IV AND TEXT FIG. A

This species is apparently the most common and widely distributed of the *Sclerotinia* species on *Carex*. It occurs throughout northwestern Europe, northeastern United States and in the Pacific Northwest. Long confused with *S. duriaeana*, its distinct identity was first suggested by the writer (Whetzel 1929: 15). In this paper I reviewed in some detail the evidence

then available to me. My study of the species in Europe in 1930 has fully confirmed that conclusion. In that paper (*l.c.*: 19–24) I described it under the name *Sclerotinia duriaeana* ("affine form"), but anticipating the correctness of my belief that it was a species distinct from *S. duriaeana* I made the combination *S. sulcata* (*l.c.*: 15). It is here again briefly characterized under its proper name.

SCLEROTINIA SULCATA (Desm.) Whetzel, Mycologia **21:** 15. 1929.

Sclerotium sulcatum Roberge *in* Herb. Desm. (in part) Ann. Sci. Nat. Ser. 3, **16:** 329. 1851.
Epidocium affine Desm. (in part) Ann. Sci. Nat. Ser. 3, **20:** 232. 1853.
Claviceps (?) *caricina* Griffiths, Bull. Torrey Club **29:** 300. 1902.
Sclerotinia duriaeana "ambiens form," Whetzel, Mycologia **21:** 15. 1929.

Spermodochidia (Figs. 8–14) scattered irregularly along the upper part of the affected culm, usually confined to that part above the first sclerotium, sometimes a few below between sclerotia; almost always confined to two faces of the 3-angled culm; distinctly linear, 2–5 mm. long by ⅓ to ½ mm. broad; dull olivaceous brown, inconspicuous especially in dry culms, splitting longitudinally when mature to release the spermatial ooze. Their structure is illustrated in Text Fig. A; *spermatia* globose about 2 μ in diam., hyaline, produced endogenously and in succession from the tips of densely clustered obclavate spermatophores, embedded in a mucilaginous matrix.

Sclerotia (Fig. 16) one to three in each culm, fusiform, ends blunt, rounded, sulcate, at first pink, then smoky gray and finally black, variable in size, depending on the slenderness of the culm in which formed, 20–25 mm. by 3–4 mm. in the large culms of *C. riparia* var. *lacustris*, 4–5 mm. by 1½–2 mm. in *C. interior*. (For a more detailed description see Whetzel 1929: 20.)

Apothecia (Fig. 15) usually but one from each sclerotium, short-stipitate, fawn-colored; *cups* deep goblet-shaped to shallow funnel-shaped when fully expanded, varying in size from 2 to 10 mm. broad, about half as deep, smooth without, membranous; *stipe* relatively short, 5–20 mm. long, smooth and concolorous with cup above, darker below; *asci* slender, clavate, apex rounded, pore J+, 8-spored, spores uniseriate, 106 meas. of asci from 6 apothecia from *C. stricta* 128–183 x 7.3 x 11 μ, mode 155.8 x 9.16 μ, av. 161 x 8.6 μ; *ascospores* hyaline, ovoid, more or less inequilateral, 205 meas. from 5 apothecia from *C. stricta* 8.8–17.5 x 5.3–8.8 μ, mode 13.1 x 7.09 μ, av. 12.6 x 6.9 μ; *paraphyses* slender clavate, hyaline.

HABITAT: In culms of *Carex* species in swamps, wet, open marshes and along banks of slow streams and ponds. Europe and North America.

LECTOTYPE SPECIMEN: Cornell University Pl. Path. Herb. *11515* on *Carex stricta* Lam., McLean, N. Y., swamp just south of Lloyd Preserve. April 26, 1921, *Whetzel*. Duplicate deposited in Kew Herbarium, Kew, England.

DISTRIBUTION: Known to me in North America only from the region about Ithaca, N. Y., Delaware and the Pacific Northwest (Oregon). It will almost certainly be found when sought throughout northern United States

PLATE III

and Canada. It is apparently common throughout northwestern Europe as the records (below) of European specimens examined would indicate. The apothecia appear early in the spring (April–May) at the time the *Carex* suscepts are beginning to flower. The spermodochidia and sclerotia begin to appear about a month later (June–July) and may be readily spotted in the dead bleached culms standing among the healthy.

ILLUSTRATIONS: Whetzel, Mycologia **21:** *fig. 1–7, 14–19*, 1929.

MATERIAL EXAMINED: In connection with my original description of this species (1929) I recorded the North American species of *Carex* then known to me, on which *S. sulcata* occurs. Since that time no additional collections of this species of special interest from North America have come into my hands. To round out the picture I present here the records of European collections which I have examined and studied: On **Carex Hudsonii** Bennett. (=*C. stricta* Good.): Desmazières, Pl. Crypt. France, Ser. II, *21*. "*Epidocium affine*" (spermodochidia only); — Lindhart, Fungi hungarici, *381*, "Peziza Duriaeana Tul." on *Carex*, Hansag, Nov. 1883 (sclerotia and spermodochidia); — Rehm, Ascomyceten, *603 a*, "Sclerotinia Duriaeana (Tul.)" on "Carex stricta Good.", Diessenhofen, Thurgau, Switzerland, Apr. 1881, "Dr. Winter" (sclerotia and apothecia); — Rehm, Ascomyceten, *603 b*, "Sclerotinia Duriaeana (Tul.) Walesellen bei Zürich, Auf faulenden Halmen, Carex stricta, 4/1893. Dr. V. Tavel" (apothecia and sclerotia); — Rabenhorst-Winter, Fungi Europaei, *2749*. "Sclerotinia Duriaeana (Tul.)" on *Carex stricta* Good., Diessenhofen, Switzerland, April 1882, *H. Wegelin* (apothecia and sclerotia); — CUPP *31566*, swamp near Fuer Sö, Jagerhuset, Denmark, June 8, 1930, *Whetzel* (spermodochidia and young sclerotia); — CUPP *31567*, along shore of Sjael Sö, Denmark, June 20, 1930, *Whetzel & Ferdinandsen* (spermodochidia); — CUPP *31568*, swamp on outskirts of Copenhagen, near Söburg, June 21, 1930. *Whetzel & Grøntved* (spermodochidia); — CUPP *31569*, Ryggmossen near Upsala, Sweden, May 28, 1931, *K. G. Ridehies* (apothecia and sclerotia). Dupl. in Herb. Univ. Upsala, Sweden. On **Carex vulpina** L.: Desmazières, Pl. Crypt. France, Ser. I, Ed. 1, *2029* and Ser. I, Ed. 2, *1629*. "Sclerotium sulcatum Rob. in herb." (spermodochidia and sclerotia); — CUPP *31576*, Upper Grimley, brick pits, Worcestershire, England, August 8, 1930, *Whetzel & C. Rea* (spermodochidia). On **Carex gracilis** Curtis: CUPP *31570*, Upton-on-Severn, Worcestershire, England, August 8, 1930, *Whetzel & C. Rea* (spermodochidia and sclerotia); — CUPP *31571*, Upper Grimley, brick pits, Worcestershire, England, August 8, 1930, *Whetzel & C. Rea* (spermodochidia and sclerotia). On **Carex inflata** Huds. (=*C. rostrata* Stokes): CUPP *31572*, swamp in woods at Nosten, parish of Bondhyrho near Upsala, Sweden, July 3, 1930, *Whetzel & Nannfeldt* (spermodochidia). On **Carex brizoides** L.: CUPP *31573*, swamp in woods at Nosten, parish of Bondhyrho near Upsala, Sweden, July 3, 1930, *Whetzel & Nannfeldt* (spermodochidia). On **Carex nigra** (L.) Reichard (=*C. Goodenowii* Gay): CUPP *31574*, swamp in woods at Nosten, parish of Bondhyrho near Upsala, Sweden, July 3, 1930, *Whetzel & Nannfeldt* (spermodochidia). On **Carex disticha** Huds.: CUPP *31575*, along shore of Lyngby Sö, Lyngby, Denmark, June 21, 1930, *Whetzel* (spermodochidia). On **Carex paradoxa** Willd.: CUPP *31578*, swamp near Fuer Sö, Jagerhuset, Denmark, June 24, 1930, *Whetzel & Buchwald* (spermodochidia). On **Carex paniculata** L.: CUPP *31579*, marsh near Faaborg, Isle of Fyn, Denmark, June 29, 1930, *Whetzel & E. Gram* (spermodochidia). On **Carex riparia** Curtis: CUPP *31580*, Knapp's brickyard, Claines, Worcestershire, England, August 7, 1930, *Whetzel & C. Rea* (spermodochidia and

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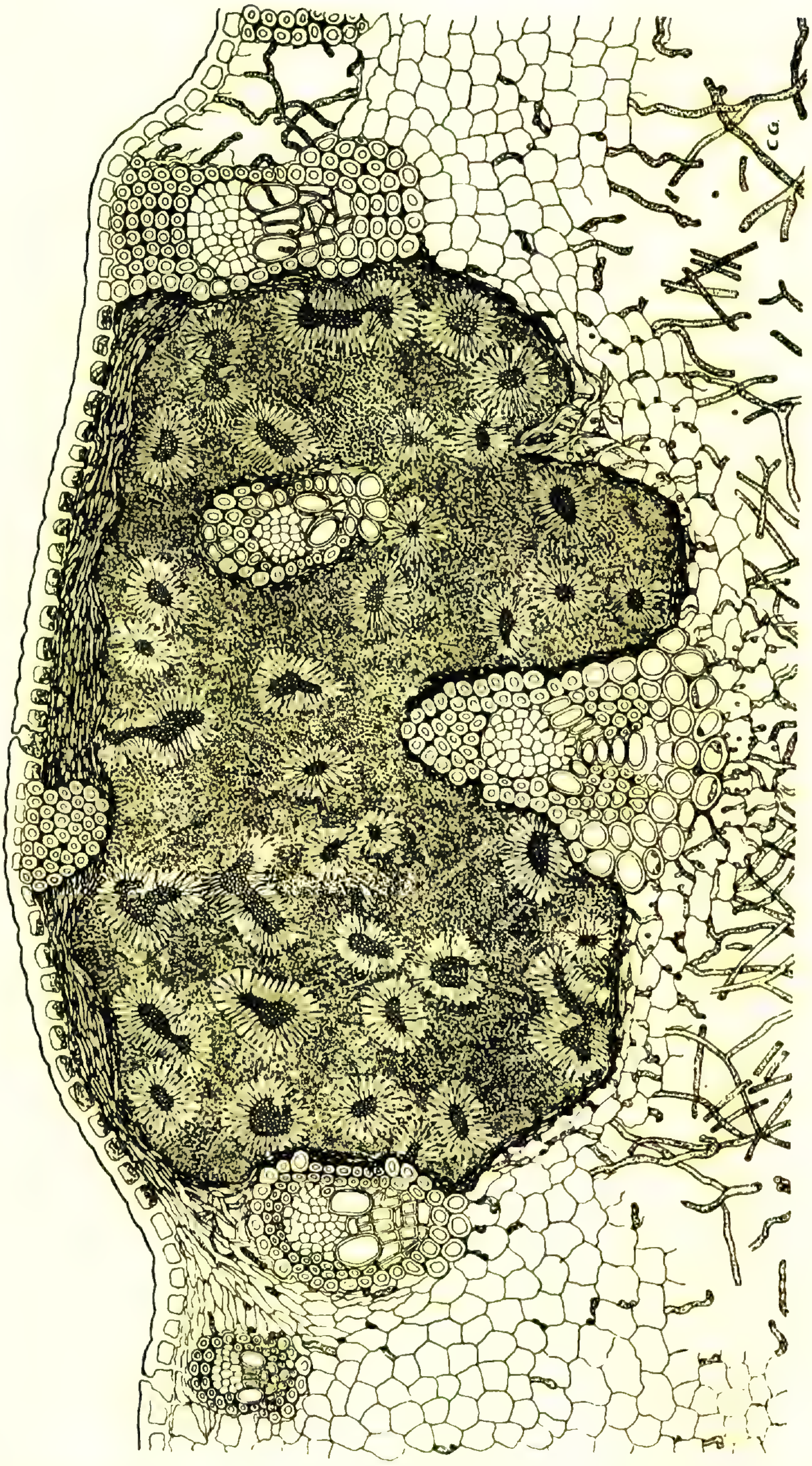
Plate 3. *Sclerotinia sulcata*. **Figs. 8–10.** Diseased culms of *C. gracilis* showing diseased inflorescence, spermodochidia, and sclerotia; natural size. CUPP *31571*. **Fig. 11.** Spermodochidia on culms of *C. vulpina*, x6. CUPP *31576*. **Fig. 12.** Spermodochidia on culms of *C. paniculata*, x6. CUPP *31579*. **Fig. 13.** Diseased inflorescence, spermodochidia and sclerotia on culm of *C. prairea*; natural size. CUPP *14947*. **Fig. 14.** Spermodochidia on culms of *C. gracilis* x6. CUPP *31571*.



Text Fig. A. Cross section through a spermodochidium of *Sclerotinia sulcata* in culm of *C. paniculata* about x325. Note that the cavity is formed by lysis of the parenchyma between the vascular bundles. Drawn by Carlos Garcés.

sclerotia); — CUPP *31581*, valley of the Avon, south of Salisbury near Woodgreen, Hampshire, England, August 4, 1930, *Whetzel & Wm. Brown* (spermodochidia and sclerotia). On **Carex** sp.: Herbarium of C. Crossland (Herb. Kew, England), "Sclerotinia Duriaeana (Tul.) Quel. Among decaying Carex etc. Masham, (Yorkshire), England. May 28, 1902" (sclerotia and apothecia).

The earliest name applied to any stage of this species is *Sclerotium sulcatum* Roberge in herb. Desm. (1851). Two years later Desmazières described the spermodochidial stage under the name *Epidocium affine*. Both of these names were based on mixtures of culms of *Carex* species and *Schoenus nigricans*, the sclerotia and spermodochidia on the latter, being those of a heretofore undescribed species of *Sclerotinia*. (See p. 421). These stages as well as the apothecia of *Sclerotinia sulcata* were long confused by European mycologists with those of *S. duriaeana*. The writer (Whetzel 1929: 15) appears to have been the first to suspect its specific identity.

The only recorded collection of this species in North America, prior to 1929, as far as I have been able to discover, was made by Griffiths and Morris in August 1901 near Andrews, Oregon on *Carex nebraskensis*. Their collection consists of sclerotia and spermodochidia only. Griffiths (1902) described the fungus under the name "*Claviceps? caricina* sp. nov." Groh (1911) having had occasion to examine this collection by Griffiths and Morris which had been distributed as West American Fungi *400*, referred it to Güssow who identified the fungus as *Sclerotium sulcatum* but erroneously referred the spermodochidia to *Epidocium ambiens*, the spermatial stage of *Sclerotinia duriaeana*.

It would appear from the recorded collections that *S. sulcata* is more common in Europe than *S. duriaeana* and goes to a greater number of *Carex* species. Both species are recorded on *C. brizoides*, *C. paniculata* and *C. disticha*. While *Carex paniculata* and its closely related species, *C. brizoides*, *C. disticha* and *C. chordorrhiza* appear to be the favorite suscepts of *S. duriaeana* in Europe, *C. hudsonii* and its North American counterpart, *C. stricta*, appear to be the most common suscepts for *S. sulcata* in North America.

SCLEROTINIA LONGISCLEROTIALIS

PLATE V

As far as I am aware, *Sclerotinia longisclerotialis* Whet. has been recorded only from North America. I kept a sharp lookout for it wherever I collected in swamps and wet marshes in western Europe during 1930, but no specimens were found which might on any grounds be referred to this species. No *Sclerotinia* species was taken there on any of the *Carex* species on which *S. longisclerotialis* is known to occur. It seems therefore probable that it is a species restricted to North America.

Although this species is described, illustrated, and discussed in full in my 1929 paper (Whetzel 1929: 24–30, *fig. 10–13, 20–23*) a brief description is here presented for the convenience of the reader. A complete list of the species on which it is known to occur, including a new suscept made subsequent to those already listed (Whetzel 1929: 30), is recorded below.

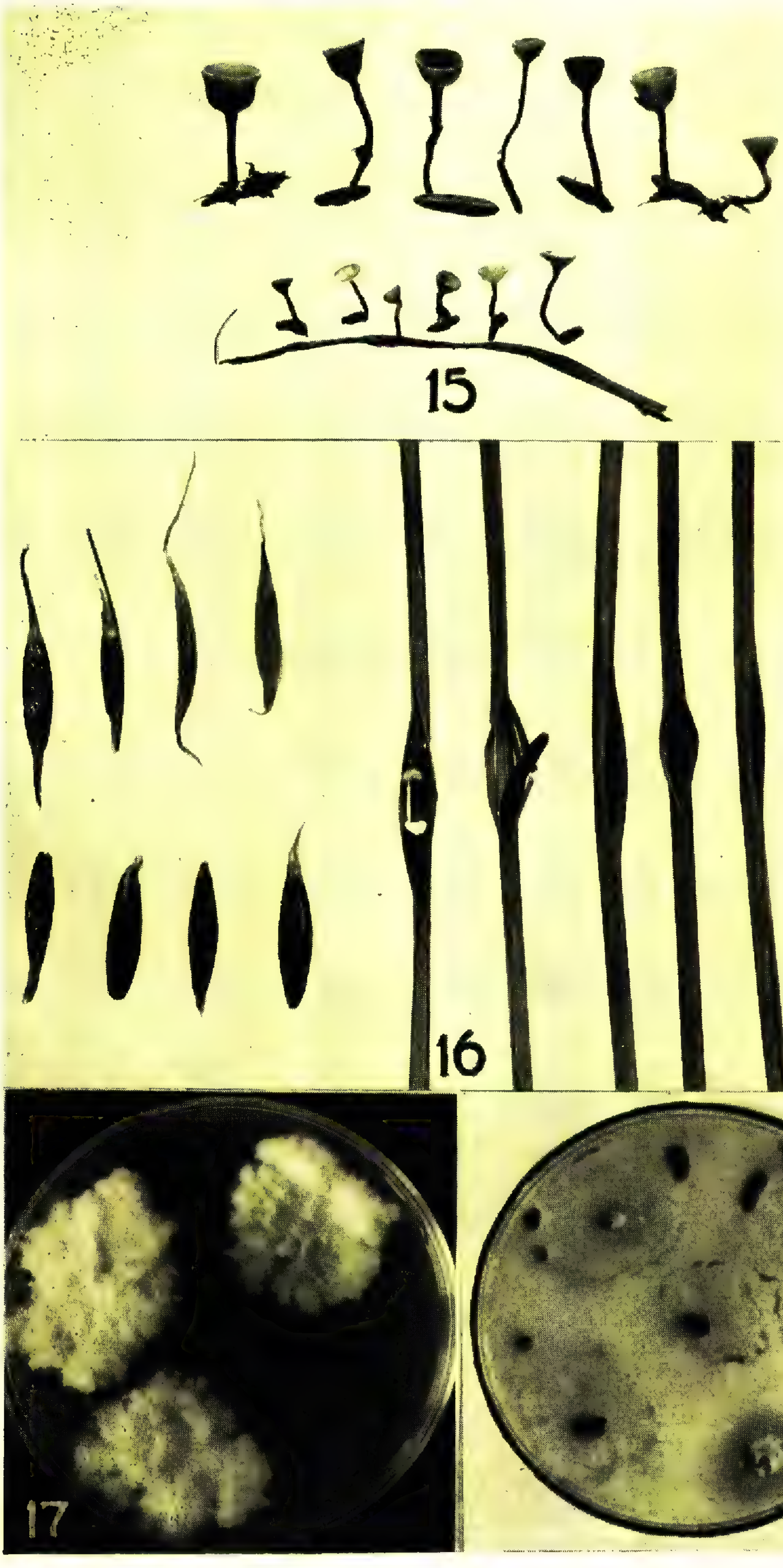


PLATE IV

SCLEROTINIA LONGISCLEROTIALIS Whetzel, Mycologia **21:** 24–30. 1929.

Spermodochidial groups (Figs. 20, 21) ovate, oblong, shining black, in pairs at rather regular intervals along two faces of the culm just below the inflorescence, rarely toward the base below the sclerotium, formed within the cortical tissues of the culm, exposed by slits in the epidermis through which ooze the mucilaginous masses of spermatia; *spermatia* globose 1–2 μ in diam., hyaline, produced in succession from the tips of obclavate spermatophores. External appearance and internal structure essentially as in *S. duriaeana* (see Whetzel 1929: *fig. 23*).

Sclerotia (Figs. 19, 22) usually one, sometimes two or more, in culm, remaining enclosed or slightly exposed by a slit in the epidermis (Fig. 20), never freed as are the sclerotia in *S. sulcata* or *S. duriaeana*, at maturity truncate, uniform in thickness, more or less 3-angled, striate due to pressure of the vascular bundles of the culm during development, at first cottony, becoming pinkish, then smoke gray, finally dull black without, the medulla white; variable in length and diameter according to the size of the infected culm, 1 cm. long by 1 mm. thick in *C. interior*, 7 cm. long by 2 mm. thick in *C. retrorsa* and 3 to 10 cm. long in *C. prairea*.

Apothecia (Fig. 19) thistle-, funnel-, or goblet-shaped with long slender stipe, one, rarely two or more, from each sclerotium; *cup* dark fawn-colored, smooth without, membranous, mouth constricted, never opening widely, 2–5 mm. broad; *stipe* slender, 10–50 mm. long, pale and smooth above, dark tomentose below; *asci* long, cylindrical, attenuate below the middle, 136 meas. from 5 apothecia from *C. prairea* gave 170–230 x 8.8–14.3 μ, mode 194 x 10.4 μ, av. 182.1 x 10.7 μ; *ascospores* strongly inequilateral, flat or incurved on one side, 289 meas. from 5 apothecia from *C. prairea* gave 12.6–22.8 x 5.3–12.5 μ, av. 18.3 x 8.1 μ, mode 21 x 9 μ; *paraphyses* slender, slightly clavate, septate.

In culture on potato dextrose agar forming an appressed feathery growth of aerial mycelium (Whetzel 1929: *fig. 20*) with distinct minute hard spermodochial masses. No sclerotia formed.

HABITAT: Open swamps and marshes where water stands throughout the year.

TYPE LOCALITY: Swamp south of the Lloyd Preserve, McLean, N. Y.

DISTRIBUTION: U. S. A.: New York and Maine; Canada: Lake Temagami, Ontario.

TYPE SPECIMEN: CUPP *10544* on *Carex prairea* Dewey, May 16, 1918. *Whetzel.*

MATERIAL EXAMINED: In addition to the specimens listed in 1929 (p. 30) on *Carex prairea* Dewey, *C. interior* Bailey, *C. vesicaria* L., *C. retrorsa* Schw., and *C. crinita* Lam. may be reported: On **C. prairea:** CUPP *17499*, McLean, N. Y. May 27, 1929 (apo-

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Plate 4. *Sclerotinia sulcata.* **Fig. 15.** Apothecia from culms of *C. stricta*; natural size. CUPP *11515*. **Fig. 16.** Sclerotia from culms of *C. stricta*; natural size. CUPP *14747*. **Figs. 17–18.** Cultures from *C. stricta* on potato dextrose agar showing cottony aerial mycelium, and sclerotia with spermodochidial masses respectively; ½ natural size. CUPP *11515* and *14747*.

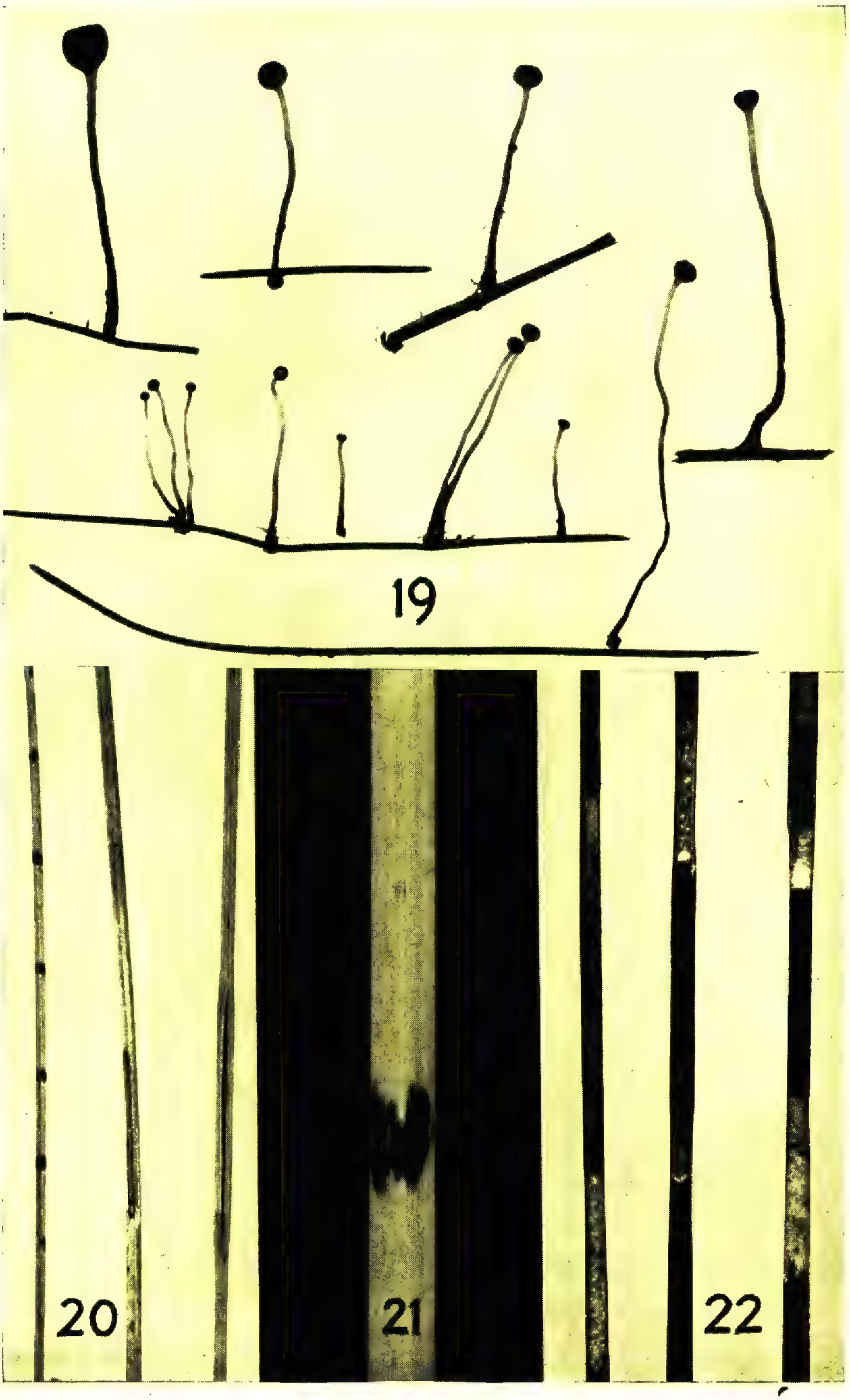

PLATE V

thecia); — CUPP *23536*, McLean, N. Y. May 14, 1934 (apothecia). On **Carex oligosperma** Michx.: CUPP *17783*, Sand Point, and CUPP *17784*, near Bear Island, Lake Temagami, Ontario, Canada, both on September 16, 1929, *H. H. Whetzel & Geo. Thompson* (spermodochidia and sclerotia).

This species is doubtless common and widely distributed in northern United States and Canada. Localities where it occurs are readily discovered by looking during late summer for the dead and bleached culms with their characteristic spermodochidia and sclerotia.

Carex oligosperma Michx. is here for the first time recorded as a suscept of *S. longisclerotialis*.

SCLEROTINIA CARICIS-AMPULLACEAE

PLATE VI

Of all the species of *Sclerotinia* known to me on sedges and rushes, *S. caricis-ampullaceae* Nyberg is the largest, the most striking, and to the eye of a mycologist, the most beautiful. This species was first brought to my attention by Dr. John Nannfeldt of the University of Upsala. He sent me in February, 1933 a collection taken June 25, 1932 near Lake Gärdsjön in Sweden. I recognized it at once as an undescribed species and proposed to Dr. Nannfeldt that I publish a description of it, naming it in his honor. Fortunately I delayed the preparation of the manuscript. A year later, in February 1934, I received another specimen of this species from Dr. Nannfeldt which had been collected in Finland. Along with the specimen he sent me a preliminary description of the species prepared by the collector, Mr. Wolmar Nyberg, who was publishing it under the name the species now bears. Nyberg, amateur mycologist and banker, had discovered it in early June 1930, in a sphagnum bog on his villa grounds near Vessö in the parish of Borgä, where it appeared each succeeding spring. Nyberg's description of which he sent me a reprint appeared in the Finnish scientific journal cited below.

During the winter of 1937–38, Dr. W. G. Solheim of the University of Wyoming told me of a remarkably large and beautiful species of *Sclerotinia* on *Carex aquatilis* which his colleague, Dr. C. L. Porter, had discovered in a high mountain swamp in the Medicine Bow Mountains, in June 1937 (Fig. 25). Duplicate specimens of Porter's collection together with abundant collections made by Solheim in 1939 and in succeeding years proved it to be conspecific with the Scandinavian collections. The extraordinary size and unusual form of the sclerotia of *S. caricis-ampullaceae* distinguish it at once from the other species on *Carex*. Although known from but three localities, its occurrence in Scandinavia and the high mountains of Wy-

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Plate 5. *Sclerotinia longisclerotialis*. **Fig. 19.** Apothecia attached to the sclerotia, from culms of *C. prairea*; natural size. CUPP *23536*. **Fig. 20.** Spermodochidia and enclosed sclerotia, from culms of *C. interior*; natural size. CUPP *15868*. **Fig. 21.** Spermodochidia, x6, from culms of *C. vesicaria*. CUPP *15860*. **Fig. 22.** Young sclerotia exposed by cutting away the culm epidermis, x2, in culms of *C. prairea*. CUPP *15872*.

PLATE VI

oming suggests that it is probably common wherever its suscepts occur throughout the sub-arctic isothermal zone.

An extensive treatment of this species is to be found in the paper by myself and Solheim (1943).

SCLEROTINIA CARICIS-AMPULLACEAE Nyberg, Mem. Soc. pro Fauna et Flora Fenn. **10:** 20–23. 1934.

Spermodochidial groups (Fig. 24) when fresh, dark colored, tuberculate, more or less spaced at intervals along the culm just below the inflorescence, exposed by slits on two faces of the culm; *spermatia* hyaline, globose to slightly ovate, 2.5–3 μ in diam., produced successively from the tips of clustered obclavate spermatophores, oozing forth in mucilaginous drops.

Sclerotia (Fig. 24) extraordinarily large, variable in size up to 20 cm. long by 1 cm. thick near the base, ventricose below with rounded or bluntly attenuated base, gradually elongated above into a slender whip-like apex, developed within the slender 3-angled culm, the base firmly nestled in the very base of the culm and the enclosing leaf bases, breaking forth through a slit in the epidermis of the culm to expose the lower half or so, the slender pointed tip remaining firmly enclosed, black without, sulcate, within pale pink to white, firm.

Apothecia (Figs. 23, 25) usually several to many, fasciculate, arising at one point on the exposed surface of the sclerotium, long-stipitate; *cup* thistle-funnel-shaped becoming more or less expanded, vinaceous brown, 4–22 mm. in diam. by 7–16 mm. deep, outside finely tomentose, relatively thin (1 mm.), membranous; *stipe* long, slender, flexuous, varying in length depending upon the depth to which the sclerotium is immersed, only the cup and upper part of the stipe protruding from the water or moss; *asci* cylindrical, attenuated below, apex rounded and thickened, pore faintly J+, 192–213 x 11.8–13.5 μ, 8-spored, spores uniseriate; *ascospores* ellipsoid, hyaline, smooth, without oil drops, 13.5–16.9 x 8.5–10 μ; *paraphyses* filiform, hyaline, branched below, scarcely enlarged toward the tips, 1–2 μ in diam.

HABITAT: In culms of *Carex aquatilis* Wahl., *C. aquatilis* Wahl, var. *altior* (Rydb.) Fern., and *C. inflata* Huds. in wet swamps and mossy bogs in sub-arctic or high mountain regions.

TYPE SPECIMEN: On *Carex inflata* Huds. (=*C. ampullacea* Good.), sphagnum bog near Vessö, parish of Borgä, Finland, June 19, 1931. Coll. W. Nyberg. Part of type deposited in CUPP *28912*. Dupl. in Bot. Inst. Univ. Upsala, Sweden.

DISTRIBUTION: Finland, Sweden, and Wyoming, U.S.A. Apothecia June–July, spermodochidia and sclerotia late summer and autumn.

Plate 6. *Sclerotinia caricis-ampullaceae.* **Fig. 23.** Apothecia from sclerotia in culms of *C. aquatilis* var. *altior* (specimen from preserving solution). CUPP *28910*. **Fig. 24.** Spermodochidia and sclerotia in culms of *C. aquatilis* var. *altior*; natural size. CUPP *29268*. **Fig. 25.** Apothecia in their natural habitat; natural size.

MATERIAL EXAMINED: In addition to the type material, I have had in hand: On **Carex aquatilis** Wahl.: — Collection made at Selet, near Lake Gärdjön, prov. Västerbotton, parish of Lövänger, Sweden, June 25, 1932, *G. Lohammar*, CUPP *21965*, (dupl. in Herb. Bot. Inst. Univ. Upsala). On **Carex aquatilis** Wahl. var. **altior** (Rydb.) Fern.: numerous collections (Whetzel & Solheim 1943: 397) made below Nash Fork bridge near Univ. Wyoming Science Camp in the Medicine Bow Mts. (alt. 9,600 ft.), Albany Co., Wyo. during the years 1937, 1939, 1940, 1941, and 1942, *W. G. Solheim & C. L. Porter*. On **Carex inflata** Huds., *Solheim*, same locality, June 27, 1942. Duplicates of all these collections are deposited in the herbarium of the University of Wyoming and the Plant Pathology Herbarium, Cornell University. The collection of apothecia made June 26, 1939 on *C. aquatilis* var. *altior* has been distributed by Solheim as *204*, Mycoflora Saximontanensis Exsiccata.

SPECIES ON ERIOPHORUM

As far as I have been able to find, there is but one species of *Sclerotinia* reported on *Eriophorum*. This is *Sclerotinia vahliana* described by Rostrup (1891: 607) from specimens collected by J. Vahl, S. Hansen and N. Harz on botanical expeditions at various times on the west coast of Greenland. The earliest collected specimen which Rostrup had before him when he described this species is presumably one collected by J. Vahl for whom he named the species. A specimen preserved in the Rostrup collections in the University Botanical Museum, Copenhagen, bears the label "E. Rostrup's Svampesamling. 1. Sclerotinia Duriaeana Tul. (Carex rigida). Nonnese 5/1829 by J. Vahl." Through the kindness of the director of the museum, Johs. Grøntved, this specimen was loaned me in September 1927 (Fig. 28). A critical examination satisfied me that this is not *S. duriaeana* and that the suscept is a species of *Eriophorum*. Whether or not this is one of the specimens on which Rostrup based his description it is now impossible to say. Since this is earliest known collection of the species and was collected by J. Vahl, I am designating it the type specimen of *S. vahliana* Rostr.

SCLEROTINIA VAHLIANA

PLATE VII AND TEXT FIG. B

Rostrup gives *Eriophorum scheuchzeri* as the suscept for all the collections he had from Greenland and lists, in addition to Vahl, two other collectors, S. Hansen and N. Harz, who appear to have made their collections during the years 1888 and 1889 (Rostrup 1891: 593). These specimens were presumably deposited in Rostrup's collections in the Botanical Museum in Copenhagen, but I have no record of having seen them when I was there in 1930.

I know of but two other collections identified as *S. vahliana*. One of these is a collection made by J. A. Nannfeldt in northern Sweden in 1927 on *Eriophorum angustifolium* and another collected by Vestergren, *et al.* in the same region in 1903 on the same species and distributed under *730*, in Vestergren's Micromycetes Rariores Selecti. These agree well in all their characters with the type collection.

During the summer of 1930 I made collections of a *Sclerotinia* attacking *E. angustifolium* (Fig. 26) in Denmark and in southern Sweden. I was able

to study only the early stages of the infection which was developing while I was there during the months of June and July. I obtained the fungus in pure culture (Fig. 27) and also found the sclerotia in early stages of development in culms in the field. Such evidence as I was able to get, indicates that the fungus in these collections is probably *S. vahliana*.

It seems desirable to present here a translation of Rostrup's original description.

"376. *Sclerotinia Vahliana* n. sp.

"Apothecia arising from a sclerotium, stipitate, brown or castaneous. Cup hemisphaerical, length and height, 4–8 mm. Stipes flexuous, tomentose, striate below, 1–3 cm. long, about 1 mm. thick. Asci cylindrical-clavate, long stipitate, length (including stipe) 150–170 μ x 8–10 μ. Spores ellipsoid, 11–14 x 4–6 μ. Paraphyses numerous. Sclerotia black, oblong, compressed, sulcate, 1 cm. long by 0.5 cm. thick.

"Between the leaf sheaths of *Eriophorum Scheuchzeri* Hoppe, Greenland (Vahl), Umanak (S. Hansen), Egedesminde, Holstenborg, Godthaab (N. Harz).

"Sclerotia assembled, 2–3, between the lower leaf sheaths, with 3–4, deep furrows along the outward turned, free side."

Based upon Rostrup's original description of the apothecia and my studies on the specimens above referred to, the following would appear to be a fairly complete description of this species.

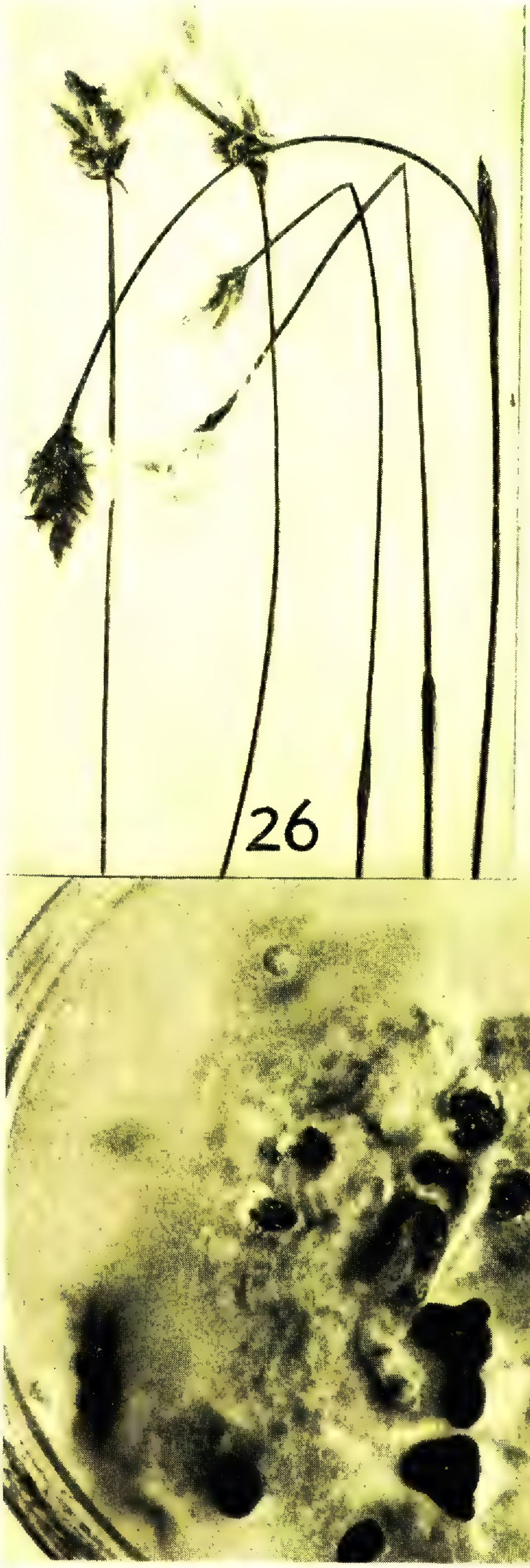
SCLEROTINIA VAHLIANA Rostr. *In* Tillaeg til "Grønlands Svampe (1888)." Meddel. om Grønland. **3:** 607–608. 1891.

Spermodochidia not found.

Sclerotia (Fig. 28 and Text Fig. B) variable in size and shape, shell-like in the form of a short, lobed half-cylinder or hollow hemisphere, up to 2–3 cm. in circumference, about 2–3 mm. thick, black without, white within, surface rough, irregularly and deeply creased, with low ridges, usually 3–4 in each culm, obviously originating within the culm but finally breaking forth to complete its growth. This peculiar morphology of the sclerotia has been recorded by Rostrup (1903: 315) who quotes a note by Ostenfeld, the collector of specimens of this species from Iceland: "Sklerotierne höjst uregemaessigt bugtet-foldede" (Sclerotia very irregularly curved and creased). The internal structure is essentially like that of other species of *Sclerotinia*.

Apothecia (Figs. 29, 30) 1–several arising fasciculately from some point on the sclerotium, broadly and deeply cup-shaped, castanean brown, short stipitate; *cup* up to 10 mm. broad by nearly as deep; *stipe* 1–3 cm. long x 1 cm. thick, flexuous, tomentose, darker than cup, black toward base; *asci* cylindrical clavate, long-attenuate below, tip rounded, not thickened, 50 meas. (type) 109–164 x 7.8–10.4 μ, mode 151.7 x 9 μ, av. 144 x 8.6 μ, 8-spored, spores uniseriate; *ascospores* long ellipsoid to fusoid, flat to concave on one side, biguttulate, 50 meas. (type) 10.8–18 x 4.8–6.6 μ, mode 12 x 5.4 μ, av. 13 x 5.6 μ; paraphyses numerous, slender, simple or branched, 3 μ diam., slightly or not at all enlarged at the tips.

In culture (Fig. 27) on potato dextrose agar forming a sparse white webby aerial mycelium; submerged mycelial mat dark olivaceous brown.



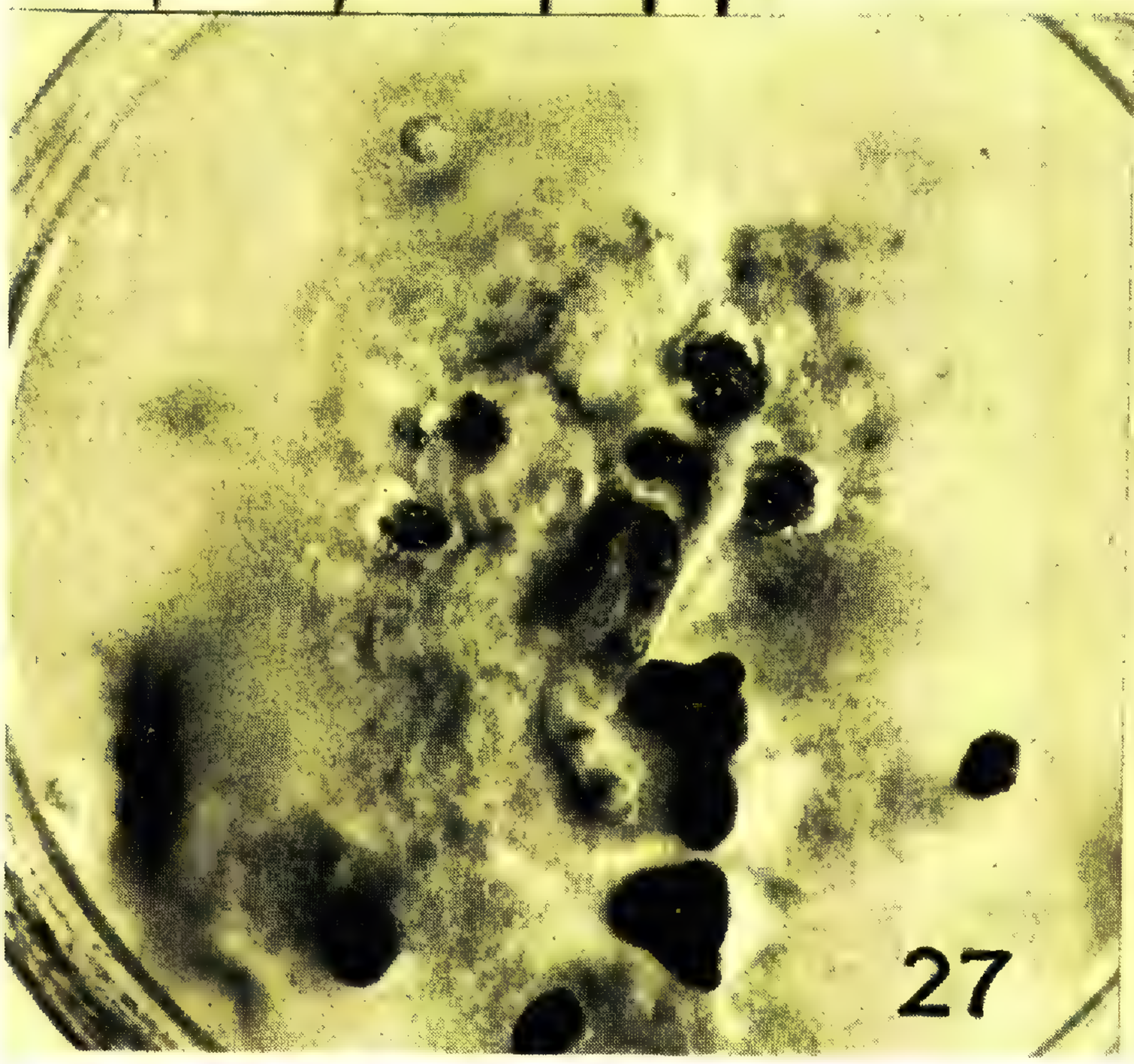


PLATE VII

Sclerotia formed abundantly, irregularly discoid or oblong, flat or low loaf-shaped (from diseased stems collected near Lyngby, Denmark).

HABITAT: In the culms of *Eriophorum scheuchzeri* Hoppe, *E. vaginatum* L., and *E. angustifolium* Roth. in sphagnum bogs, apothecia, May–July; sclerotia, late summer and autumn. An arctic and sub-arctic species.

DISTRIBUTION: Reported from Greenland (Rostrup 1891 and 1906), and Iceland (Rostrup 1903 and Larsen 1932). Known to me from Denmark and Sweden. Should be found in the arctic and sub-arctic zones of continental North America.

TYPE SPECIMEN (Fig. 28): The collection by J. Vahl on *Eriophorum* (*scheuchzeri* ?) Nonnese, Greenland, May 1829. Deposited in the Botanical Museum, Copenhagen, under the name, "*Sclerotinia Duriaeana* Tul." Photograph and microscopic mount deposited in CUPP *16275*.

MATERIAL EXAMINED (in addition to the type specimen): On **Eriophorum vaginatum** L.: CUPP *31589*, sphagnum bog along north shore of Lyngby Sö, Lyngby, Denmark, June 7, 1930, *H. H. Whetzel* (early stages of infection); — CUPP *31591*, swamp in forest at Nosten, parish of Bondhyrho, near Upsala, Sweden, July 3, 1930, *H. H. Whetzel & J. A. Nannfeldt* (early stages of infection). On **Eriophorum angustifolium** Roth. (=*E. polystachon* L.): Vestergren, Micromycetes Rariores Selecti, *730*. Lapponica Tornensis, Vassijaure (Sweden), July 1903, *A. Roman, N. Sylvén & T. Vestergren* (apothecia and sclerotia); — "Fungi Suecici". University Upsala. Dupl. N. Y. Bot. Gard. and CUPP *31606*. Collected in Torne, Lappm. Jukkasjarvi. s:n. Abisko, Sweden, June 30–July 5, 1927, *J. A. Nannfeldt* (apothecia and sclerotia); — CUPP *31590*, swamp in forest near Nosten, parish of Bondhyrho, near Upsala, Sweden, July 3, 1930, *H. H. Whetzel & J. A. Nannfeldt* (early stages of infection).

This species is very distinct from the others in cyperaceous suscepts, being especially marked by the unusual form and development of its sclerotia. While I think that the *Sclerotinia* which I found in its early infection activities in the culms of *E. vaginatum* and *E. angustifolium* in Denmark and Sweden is probably *S. vahliana*, it is unfortunate that I was not early enough in the localities to get the apothecia and did not remain late enough in the summer to follow the development to mature sclerotia. I feel quite sure that spermodochidia of some type would have developed during late July or August in the infected culms. Tiny masses of densely protoplasmic, large, thin-walled hyphae, which are present at intervals in the diseased culms which I preserved (CUPP *31589*) are characteristic of the initial stages of spermodochidial development in the other species of the cypericolous species of *Sclerotinia*.

The sclerotia of *S. vahliana* appear to have an unusual history of development (see Text Fig. B). They are initiated as in the related species, within the culms of the suscepts. I was able to observe only the early stages in

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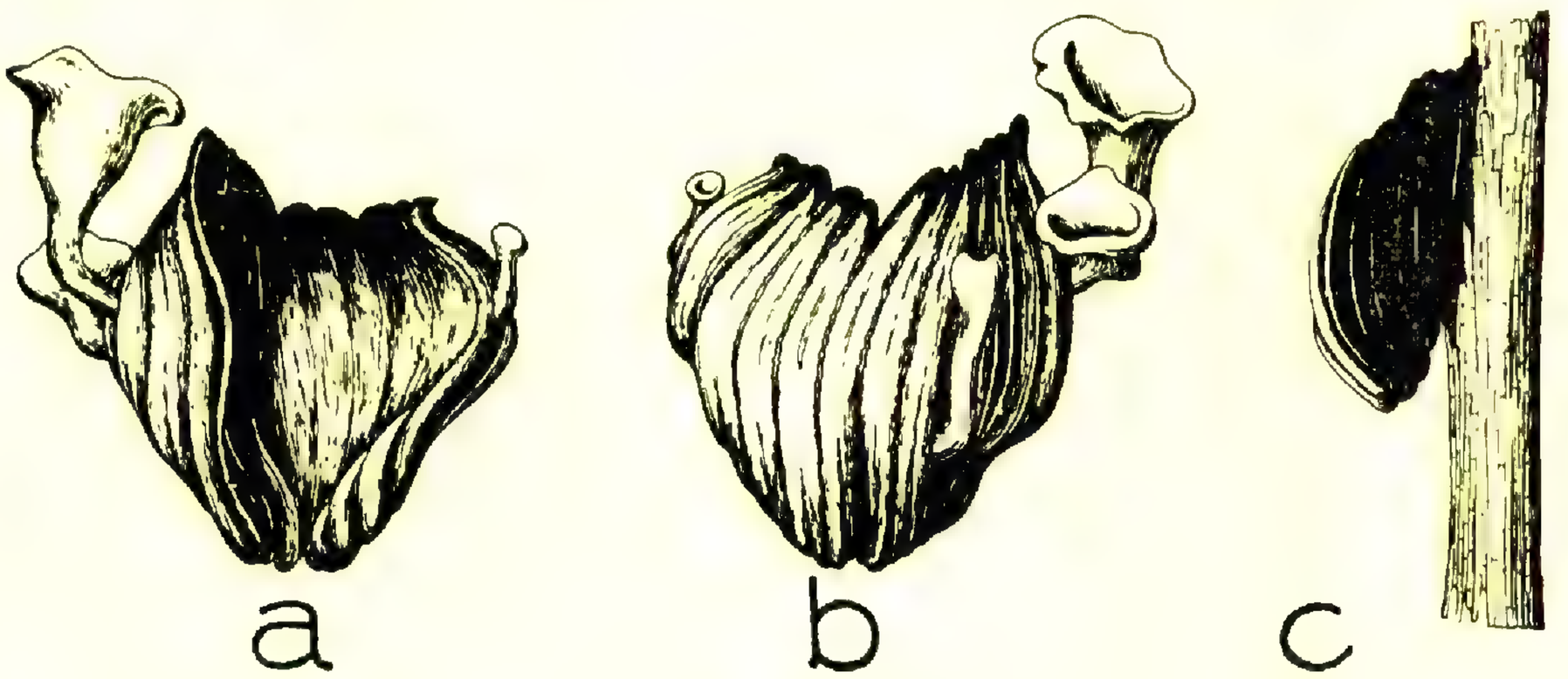
Plate 7. *Sclerotinia vahliana*. **Fig. 26.** Diseased culms of *Eriophorum vaginatum*; ½ natural size. CUPP *31589*. **Fig. 27.** Culture from culms of *E. vaginatum* on potato dextrose agar showing sclerotial formation; natural size. CUPP *31589*. **Fig. 28.** Type specimen in Botanical Museum, Copenhagen (revived dry material); natural size. CUPP *16275*. **Figs. 29–30.** Apothecia on sclerotia from *E. angustifolium* from Sweden (revived from liquid preservative); natural size. CUPP *31606*.

this development. The sclerotia begin as elongate, cottony, white masses at three or four places in the culm. As the young sclerotia begin to solidify they become pink in color as do those of related species. In a few cases I found evidences of the developing rind. I found no mature sclerotia, all being still firmly enclosed within the culms. I observed that the infected culms often appeared to be stouter and apparently to have been more vigorous in their growth than were the healthy ones. This may have been due to stimulation by the fungus during the first days of infection. As far as I was able to discover, these sclerotia were developing only in the upper internode of the culm in *E. vaginatum*. It seems almost certain, however, that sclerotia are formed at intervals throughout the culms even to the base. They apparently do not complete their development within the culm but,



TEXT FIG. B

Text Fig. B. Sclerotium of *Sclerotinia vahliana* from base of culm in crown of *Eriophorum*, (a) front and (b) back view, (c) from one higher up in culm; all x2. Drawn by Miss Charlotte Dill.

bursting out, continue to grow in size. The mature sclerotia I have seen bearing apothecia are obviously too large to have fully matured within the culms.

Rostrup's description of the sclerotia as "assembled between the lower leaf sheaths" suggests that in the dwarfed *Eriophorum* plants of Greenland and Iceland, they may be formed chiefly in the basal region of the culm. However, I have seen specimens of sclerotia bearing apothecia which had clearly developed in the upper reaches of the culm (*e.g.* Nannfeldt's collection of 1927, Text Fig. Bc). Careful observations in the field may disclose, in the case of sclerotia clustered in the crowns of the suscepts, that the base of the leaves as well as the culm have been involved in the nourishment of these sclerotia. Larsen (1932), in recording the occurrence of this species in Iceland, cites collections by himself and by Ostenfeld and remarks, "On tufts of Carex and Eriophorum on swampy ground. The pea-sized sclerotia are often seated in the axils of the leaves, covered by the leaf sheaths". It is very doubtful that *S. vahliana* ever attacks *Carex* species. Larsen is either

in error or has confused some species of *Sclerotinia* actually occurring on *Carex* in Iceland, with *S. vahliana* on *Eriophorum*.

SPECIES ON SCIRPUS AND SCHOENUS

A species of *Sclerotinia* on *Scirpus lacustris* L., long known to European mycologists, chiefly in its sclerotial stage, was finally described by Rehm (1896) under the name of *Sclerotinia scirpicola*. Although represented in herbaria by but few collections, it is certainly common and widely distributed throughout northwestern Europe. It is not known from North America. No species of *Sclerotinia* is known to occur on other species of *Scirpus*. Ferdinandsen & Winge (1911: 293) report a collection by Ade in Bavaria, Germany, said to be this species on *Scirpus silvaticus* ("the spores finally becoming 2-celled"). Since the spores of *S. scirpicola* are uniformly 1-celled, it is very doubtful that Ade's specimen was correctly determined. There is however a species, pathogenic to the closely related *Schoenus nigricans* L., which appears to have been generally overlooked by mycologists.

SCLEROTINIA SCIRPICOLA

PLATE VIII AND TEXT FIG. C

This species is of peculiar interest because of the nice adaptation it has made to its aquatic habitat. Its suscept is an inhabitant of the shallow waters of lakes and ponds. Not only do the freed sclerotia float like tiny corks upon the water but in the spring the apothecia develop on these where they accumulate in thousands on the low flat shores as the water subsides. Aside from the original description of the apothecial stage by Rehm (based upon dry material) the papers by Ferdinandsen & Winge (1911 and 1913) and Sydow's (1912) appear to be the only contributions of importance dealing with this species. During my stay at Lyngby, Denmark, during June 1930, an exceptional opportunity was afforded for study of *S. scirpicola* as it occurs in Lyngby Sö. As a result of these studies a more complete picture of this species can now be drawn.

SCLEROTINIA SCIRPICOLA Rehm *in* Rabenh. Krypt. Fl. **1**[3]: 822. 1893.

Sclerotium roseum Moug. *in* Fries, Syst. Myc. **2** (Suppl.): 43, 1830. (=Elench. Fung. **3:** 43. 1828).

Sclerotium roseum Kneiff *in* Duby, Bot. Gall. **2:** 874. 1830.

Sphacelia scirpicola Ferd. & Winge, Biolog. Arbej. Tilegnede, Warming, Nov. 3, p. 290. 1911.

Myrioconium scirpi Syd. Ann. Myc. **10:** 449. 1912.

Myrioconium scirpicola V. Höhn. Mitt. Bot. Inst. u. Tech. Hochsch. Wien **3:** 50. 1926.[6]

Spermodochidial groups (Figs. 31, 32) more or less oval to elongate, shallow, slightly raised, very variable in size, often minute, irregularly

[6] Ferdinandsen & Winge (1913: 24) admitted the logic of Sydow's argument (in a letter) for referring the conidial stage of *S. scirpicola* to his genus *Myrioconium* but they did not actually make the combination *M. scirpicola*, as Von Höhnel seems to imply in this 1926 paper.

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PLATE VIII

disposed along one side of the culm for some distance just below the heads, dull black, rupturing by slits in the epidermis, from which the viscid mass of spermatia are discharged; *spermatia* minute, globose, about 3.3 μ in diam. The dark color of the spermodochidial groups is due to the brownish color of the massed spermodochia, the brown gummose contents of the epidermal cells, and to brown-walled intercellular hyphae in some of these cells.

Sclerotia (Fig. 34) usually 8–10 per culm, the first one developing with the appearance of the spermodochidia and just below them; successive sclerotia appear a few inches apart as the invading hyphae spread downwards in the culm. The sclerotia originate as soft pinkish mycelial masses in the loose central parenchyma of the culm, at maturity appearing as large, longitudinally lobate, oblong, blunt, black, tuberoid bodies completely enclosed in the culm. The culms, weakened at these points, are easily broken by the wind, discharging the sclerotia into the water, where they float, and drifting with the wind, accumulate, together with broken pieces of the culms, in great patches along the leeward shores of the lake or pond. The sclerotia vary much in shape and size, being usually somewhat longer than broad, ranging from 2–10 mm. by 2–5 mm. in diameter. The form of the sclerotium is striking, being elongately 2–3-lobed, the ends of the lobes blunt and rounded. This compound appearance is more apparent than real, being due to the structure of the culm. A cross section of the sclerotium discloses a narrow outer black rind, one to two cells thick, enclosing a medulla of rather loosely interwoven, relatively thin-walled, large hyphae, distinctly septate and often constricted at the septa. The medulla long retains its bright pink color, even after the formation of the rind, but eventually becomes white. The lobation of the sclerotium is marked out in the cross sections by faint brown lines, the persistent brownish-walled cells which formed the firmer tissues surrounding the cavities originally filled with thin-walled pith cells which have been largely digested by the developing sclerotium.

Apothecia (Figs. 34, 35) appearing in the spring at flowering time of the *Scirpus*; 1–to several from each sclerotium, usually not more than 2, arising at any point on the sclerotium, variable in size, when fully expanded 3–15 mm. in diam., av. 8–10 mm. The size of the apothecium apparently does not depend entirely upon the size of the sclerotium for several, all usually small, or one much larger than the others may arise from a single sclerotium; *cups* deep goblet-shaped becoming nearly flat expanded, light fawn to vinaceous brown, lighter beneath, due to a coating of fine hyphal fuzz; *stipe* usually short, slender, concolorous with under side of the cup, also covered with a hyphal fuzz above, clothed below, especially at the base, with a dense mat of long, dark hyphae which serve to anchor the large apothecia to the

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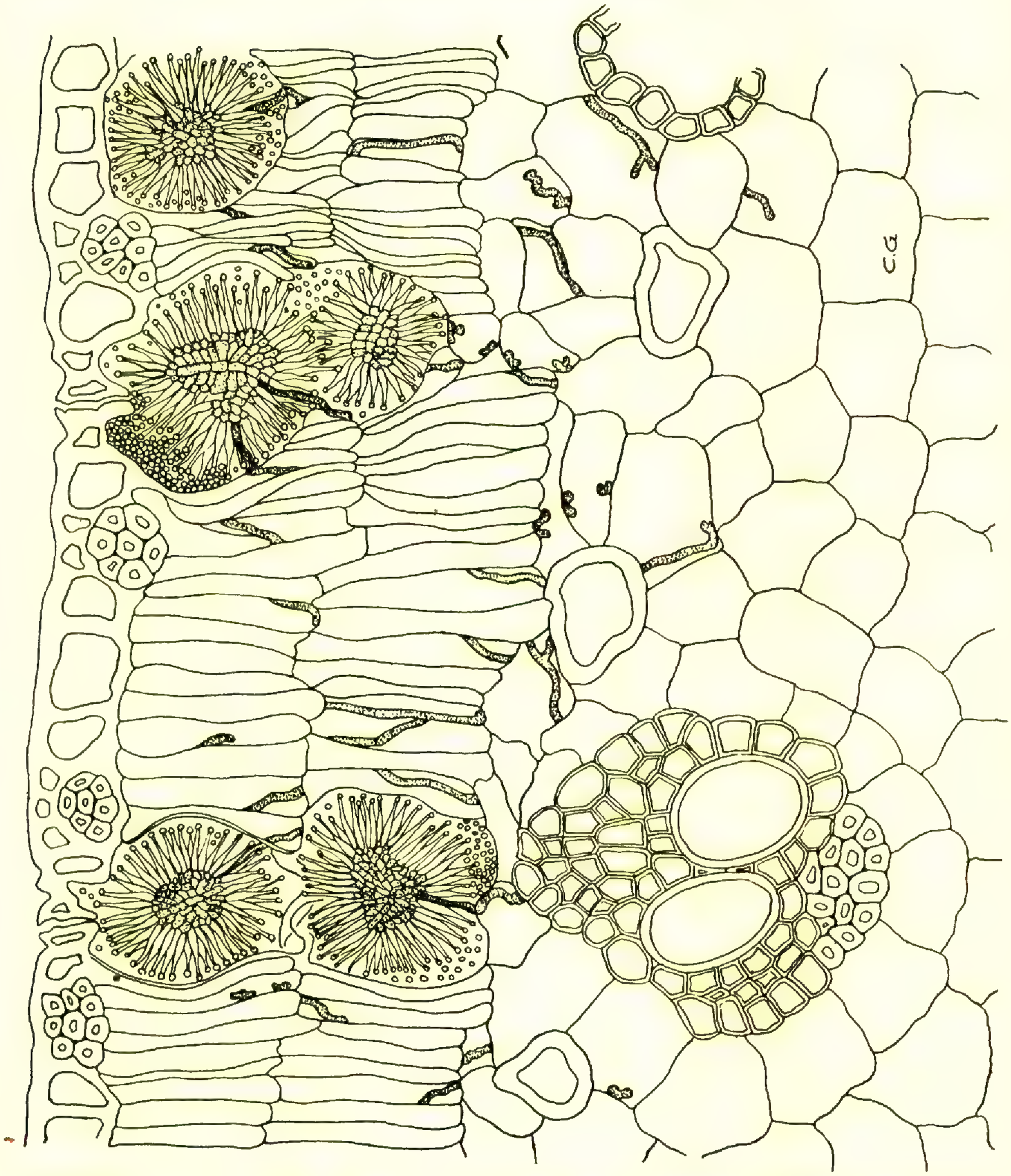
Plate 8. *Sclerotinia sctrpicola.* **Fig. 31.** Diseased culms and inflorescence of *Scirpus lacustris* showing spermodochidia; about natural size. **Fig. 32.** Part of culm showing spermodochidia, x6. **Fig. 33.** Showing method of inoculating pistils of *S. lacustris* for study of invasion phenomena; about natural size. **Fig. 34.** Sclerotia and young apothecia; natural size. **Fig. 35.** Sclerotia bearing mature apothecia; natural size. All from specimens in CUPP *31607*.



Text Fig. C. Cross section through spermodochidia of *Sclerotinia scirpicola* about x400. Note that each cavity is directly beneath a stomate, and is formed chiefly by crowding aside the palisade cells rather than by digesting them. Drawn by Carlos Garcés.

surrounding floating debris of broken culms; *asci* long, cylindrical, apex blunt, of about the same diameter throughout, except at the base where they are rather sharply narrowed to about half the diameter of the apical portion, 8-spored, spores uniseriate in the upper third of the ascus, 50 meas. (fresh, in water) 133.3–181.8 x 8.1–10.8 μ, mode 157.5 x 9.5 μ, av. 153.2 x 9.4 μ; *ascospores* long oval, 100 meas. (fresh, in water) 11.2–17.8 x 5.3–7.9 μ, mode 13.8 x 6.6 μ, av. 14.4 x 6.6 μ surrounded by a very evident mucilaginous coat; on germination in water often producing spermatophores and spermatia directly; *paraphyses* slender, not appreciably swollen toward the tips, about 3.4 μ in diam.

In culture on potato dextrose agar forming a thin, white, aerial, webby coating over the surface of the agar; submerged mycelium feathery as in cultures of *S. longisclerotialis*; no sclerotia formed.

HABITAT: In the culms of *Scirpus lacustris* L. in the shallow waters of lakes and ponds. Apothecia developing on sclerotia stranded along the shore line among sedges, grasses and other plants which afford continuous shade and moisture during their development.

DISTRIBUTION: Throughout western Europe; very abundant in Denmark (Ferdinandsen & Winge 1911: 293). Also reported from Finland, Germany, Sweden, and England. Probably to be found in equal abundance when sought in neighboring regions of northern Europe; not known from North America.

TYPE SPECIMEN: The specimen upon which Rehm (1893: 823) based his original description of this species, was found by him in Winter's herbarium. He says it bore the label "Peziza tuberosa" with the notation (transl.) "in May, the old culms of *Scirpus lacustris*, in our lakes break up. When these fall into the water, this Peziza appears from sclerotia in a few days, from every piece which with us very frequently contains *Sclerotium roseum* (Moug.) Fries." According to Rehm the specimen was probably collected by Winter in Saxony near Zweibrücken in the Rheinpfalz (Germany). I have been unable to discover where this type specimen (if indeed it is still extant) is now deposited.

ILLUSTRATIONS: Ferdinandsen & Winge, Saertryk af Biol. Arbej. Tilegnede. Eug. Warming. Nov. 3, *fig. 1–7*. 1911.

MATERIAL EXAMINED: Exsiccati Specimens: In the Kew Herbarium there is a specimen of three pieces of culm each with an enclosed sclerotium labeled "Sclerotium roseum" with a brief written description signed by Persoon. The specimen is unnumbered, undated and locality where collected not indicated; — Mougeot et Nestler, Stirp. Crypt. Vogeso-Rhen. *884* (1826). "*Sclerotium roseum* Kneiff-Pers.-Fries. in Litt." Specimens of this in the British Museum, in Kew, and at Cornell show sclerotia in culms said to have been collected near "Argenoratum", now Strassburg, in Alsace, France. Collected by Kneiff in autumn. No date of collection given; — Kneiff et Hartmann; Pl. Crypt. Badens, *20*, 1828. "Sclerotium roseum Kneiff (nov. sp.)". This specimen in the British Museum consists of pieces of culms containing mature sclerotia collected in canals along the Rhine near Kehl in Germany. Sept.–Oct. No year of collection given and no collector cited; — Klotzsch, Herb. Mycol. *244* (1842). "Sclerotium roseum Moug. Intra culmos Scirpi lacustris ad Dresden". This specimen in Kew Herbarium bears only the data above quoted. It consists of a piece of culm containing a sclerotium; — Roumeguère, Fung. Gallici Exs. *499*, 1879. "Sclerotium roseum Kneiff. Pers. Fries. in Litt. Moug." This number was made up from material remaining in Mougeot's herbarium and is of the same origin as his Stirp. Crypt. Vogeso-Rhen. *884*. Specimens examined in the Kew Herbarium and in CUPP show a single sclerotium in a piece of culm; — Otto Jaap, Fung. Sel. Exs. *755*. Collected by Jaap in Brandenburg, Triglitz in the Prignitz, Germany. June 15, 1916 (spermodochidia (?), sclerotia and apothecia); — Flora Suecici *4222*. Collected by J. A. Nannfeldt on shore of shallow arm of Mälaren. Bondkyrok s:n. Skarholmen, Uppland, Sweden. June 25, 1931 (apothecia). Dupl. CUPP *32615*; — In Kew Herbarium a specimen labeled: "*Sclerotinia scirpicola*, Ashgrove Loch, Shevenston, Ayrshire 26.2.21. Coll. D. A. Boyd." Consists of a single culm of *S. lacustris* containing a single sclerotium; — CUPP *31607*, along the shore of Lyngby Sö, Lyngby, Denmark, June 3–July 13, 1930, *H. H. Whetzel* (spermodochidia, sclerotia, apothecia and cultures). Duplicate specimens from this collection have been distributed

to the following herbaria: Kew, England; British Mus., London; Univ. Toronto, Canada; Farlow Herb., Cambridge, Mass.; N. Y. Bot. Gard.; Univ. Mus., Ann Arbor, Mich.; Missouri Bot. Gard., St. Louis, Mo.; Mycol. & Pl. Dis. Survey, Bur. Pl. Ind., Washington, D. C.; Univ. California, Berkeley; Univ. Iowa, Iowa City.

The abundance of apothecia in Lyngby Sö during my stay in Lyngby, and the nearness of laboratory facilities for critical studies and culture work, presented an opportunity not to be neglected. I devoted most of my time to such studies, the results of which are summarized below.

LIFE HISTORY STUDIES

The life history of *S. scirpicola*, while in general quite like that of its near relatives on *Carex* species, presents some unique features largely due to the habits of its suscept *Scirpus lacustris.* This *Scirpus* grows in the shallow waters along the shores of the lake. It is most vigorous and fruits most luxuriantly near the shore, the plants becoming more scattered, shorter and usually producing fewer flowering culms as the plantation spreads out into the deeper water. When we arrived at Lyngby, the first week in June 1930, I found the apothecia already developing in great abundance from the thousands of sclerotia lodged in debris on low-lying projections of the shore, a few minutes' walk from the laboratory of the Phytopathological Experiment Station in which we were kindly afforded working facilities by the Director, Mr. Ernest Gram. The shores of this shallow lake are fringed with great patches of *Scirpus lacustris* and the prevailing southwest winds of the previous fall and winter had deposited the sclerotia in immense numbers along with the broken culms of *Scirpus* just above the receded water level on every flat projection of the northeast shore of the lake and on the water where they were anchored and shaded by a rich growth of grasses and other shore-loving plants and shrubs. The open apothecia reached their maximum abundance about the end of the first week in June. A week later most of the apothecia were shrivelling or decaying, though new ones were still to be found just sprouting from sclerotia here and there. By the 17th of June, only an occasional apothecium was to be found. Many heads of the *Scirpus* were already in bloom on June 2 when we arrived, but blossoming reached its maximum about the time apothecia were to be found in greatest abundance. The weather throughout June was warm, the skies clear, and practically no rain fell. From the abundance of mature apothecia at the beginning of June, we judge that they must have begun to open about the middle of May. This would indicate that the period of apothecial production normally extends over a period of three to four weeks.

The mature apothecia discharge their ascospores in tiny puffs which, caught by gentle air currents among the shading vegetation, are wafted upward, some of them eventually reaching the white extruded pistils of the *Scirpus* inflorescence, where they lodge on the feathery stigmas. By suspending open apothecia over the inflorescence (Fig. 33) of culms (with cut ends in water) placed under an inverted large test tube, I was able to obtain naturally inoculated pistils. These when removed and mounted on glass slides the following morning, afforded excellent material for study of spore

germination and penetration. The spores germinate promptly, sending out from one end a stout simple germ tube. This penetrates the projecting hyaline cells of the stigma, usually forming a swollen globose appressorium where the tip has applied itself to the surface of the stigmatic cells. From this appressorium a penetration tube is sent into the cell from which an invasion hypha passes down into the tissues of the pistil. Infection is promptly indicated by the browning and shrivelling of the pistils. Uninoculated pistils remain white and plump for several days under the same conditions. The fungus having entered the ovary, growth seems to be greatly slowed down. In the open, about two weeks after inoculation, one or more of the peduncles supporting the individual spikes of the inflorescence begin to turn brown, the mycelium having killed the spike and spread downward into the peduncle through which it reaches the main stalk of the culm.

A dark browning just below the point of attachment of the inflorescence announces the invasion and infection of the culm proper. Visible infection of the culm becomes evident about three weeks after inoculation, as Ferdinandsen and Winge had already discovered. Rapid progress of the infection down the culm, however, does not usually occur for another week or so. It is evidenced by a hydrotic discoloration of the culm, with disappearance of the chlorophyll and discoloration in the form of alternating broad bands of a light and dark brown color. When this zonation has extended a foot or so down the culm, the spermodochidial groups begin to appear in an irregular line on one side of the culm in the brown necrotic tissues several inches below the inflorescence (Fig. 31). These spermodochidial areas are very variable in size, ranging from mere specks to elongate or irregularly ovate, black, slightly raised patches just beneath the epidermis. They are usually very numerous and the tissues in which they develop are generally of a distinctly lighter brown color than the adjacent regions. They finally rupture by slits, discharging the viscid masses of spermatia as the first sclerotial initials are to be detected just below. The downward progress of the fungus, indicated by hydrosis and zonate discoloration, now proceeds rapidly with the successive formation of sclerotial initials at intervals of a few inches. As many as ten to fifteen sclerotia may appear in a long vigorous culm, according to Ferdinandsen and Winge. When we left Lyngby on July 15, the first sclerotia were just beginning to appear occasionally in an infected culm.

As the sclerotia mature, they rupture the epidermis over them by several slits. The dead culms, weakened at these points, are gradually broken over by the winds of late summer and autumn. The breaking up of the ice in the spring by storms completes the breaking up of the culms, freeing the sclerotia which float on the surface of the water and are thus transported by the waves to their final resting place among the debris along the shore, ready to germinate and produce apothecia under the favorable conditions of temperature, shade, and moisture prevailing at the blossoming time of the *Scirpus*.

Ascospores discharged onto potato dextrose agar or disinfested segments of infected culm of *Scirpus* planted in the same medium give identical mycelial growths. Growth both from ascospore sowings and from tissue plantings is prompt and vigorous, like that of *S. sulcata.* Aerial mycelium is abundant, usually loose and cottony, at first pure white (never pink) becoming denser with age and faintly brownish, often with large dense masses of a dirty grey color, especially in test tube slants. The submerged mycelium becomes blue black at the center of the colony with radiating dark brown feathery strands. Spermodochia were not observed on this medium. Sclerotia were only tardily developed on test tube slants but were numerous in Petri dish cultures, being globose, black outside, pink where they grow against the glass and more or less completely buried in the dense aerial mycelium.

Although the morphology and life history of *S. scirpicola* are now perhaps more fully known than those of any of the related species on cyperaceous suscepts, a number of features require further consideration.

It seems probable that some of the sclerotia may remain dormant through the summer following their formation, as numerous hard, plump, ungerminated sclerotia were found among the debris along the shore of Lyngby Sö long after the last apothecia had disappeared. On the other hand, these sclerotia may not be capable of germination for some unknown reason.

The germinability of the sclerotia may be conditioned in some way by the functioning of the spermatia. The writer's original suggestion (Whetzel 1929: 18) that the microconidia probably function as do the spermatia of the rusts has since been supported by the work of Drayton (1934) in his work on *Sclerotinia gladioli.* Ferdinandsen & Winge (1911: 297) think the microconidia may function as true conidia, causing secondary infections later in the season when primary infections by ascospores are no longer possible. This seems very doubtful though they cite some observations in support of this hypothesis. The writer has had no satisfactory opportunity to attempt a careful study of the germination and role of the spermatia, but believes that *S. scirpicola* is a favorable species for such an investigation. It occurs in great abundance in Lyngby within easy walking distance of excellent laboratory facilities. It is to be hoped that Professor Ferdinandsen or some of his students will undertake intensive investigation on this very interesting and important problem, as they are most favorably situated for such an undertaking.

The suggestion of Ferdinandsen and Winge that invasion by the fungus takes place through the culm at some point just below the inflorescence does not appear tenable. Ascospores shot on to culms at this point, in moist chambers, were observed to germinate poorly or to produce spermatia only. No germ tubes could be found penetrating the epidermis or entering through the stomata, which are numerous all over the culm, while actual invasion of the stigmas was easily demonstrated. The death of the pedicles of infected spikes prior to the first evidences of infection in the culm itself also argues for blossom invasion. While the very limited and preliminary

investigations which we have been able to make all point definitely to the pistils of the *Scirpus* as the infection court, more extensive studies and inoculation experiments should be made.

ORIGIN AND RELATIONSHIPS

Undoubtedly *Sclerotinia scirpicola* is very closely related to the species on *Carex*. It differs from these chiefly in the characters of its spermodochidia and sclerotia. On the whole, it approaches more nearly *S. sulcata* rather than *S. duriaeana*, as suggested by Ferdinandsen and Winge who, however, at that time were not aware of the fact that there were two distinct species confused under the name *S. duriaeana*. Its similarity to *S. sulcata* is most marked in its cultural characters. Its dense cottony growth of aerial mycelium and large tuberoid sclerotia produced on potato dextrose agar are scarcely to be distinguished from those produced by *S. sulcata* in pure cultures. Sclerotial production on potato dextrose agar is, however, much more tardy and less certain, while the growth of aerial mycelium is generally more abundant; the submerged mycelium is also more promptly and extensively darkened. Its spermodochidial patches also simulate those of *S. sulcata* in their irregular distribution on the culm. The form of its sclerotia in nature is quite distinct but may possibly be due entirely to the structure of the *Scirpus* culm. It is probably restricted in its pathogenism to *Scirpus*. Many *Carex* species were common about the shores of Lyngby Sö, but only two or three apothecia arising from sclerotia of the *Carex* type were found among the apothecia of *S. scirpicola* along the lake shore. Cultures from one of these proved to be typical of *S. duriaeana*. Infected culms of *C. disticha* in the same locality yielded typical cultures of *S. sulcata*. Moreover, the period of apothecial development is distinctly later for *S. scirpicola* than for the species on *Carex*. Apothecia of the species on *Carex* were rarely to be found about Lyngby when we arrived at the beginning of June, although infection of the culms of *C. Hudsonii* by *S. sulcata* were discovered in abundance shortly after our arrival. The blossoming period for *Carex* species was also practically past. Since two to three weeks are required for the development of visible infection after inoculation by *S. duriaeana* or *S. sulcata* in their *Carex* suscepts, the scarcity of apothecia of these species when those of *S. scirpicola* were at their optimum abundance is significant In spite of all this evidence as to the specific identity of *S. scirpicola*, careful cross inoculation experiments should be made with this form on species of *Carex* known to be suscepts for *S. sulcata* and *S. duriaeana*. Here is another interesting problem for some energetic young pathologist or mycologist who can avail himself of the exceptional opportunity afforded there at Lyngby.

The marked similarity of *S. scirpicola* to *S. sulcata* appears to be of considerable significance in connection with my theory of the origin and evolution of this group of species on cyperaceous suscepts. It would seem that *S. scirpicola* has been a relatively recent differentiation derived directly from the European form of *S. sulcata*, which is probably also the mother

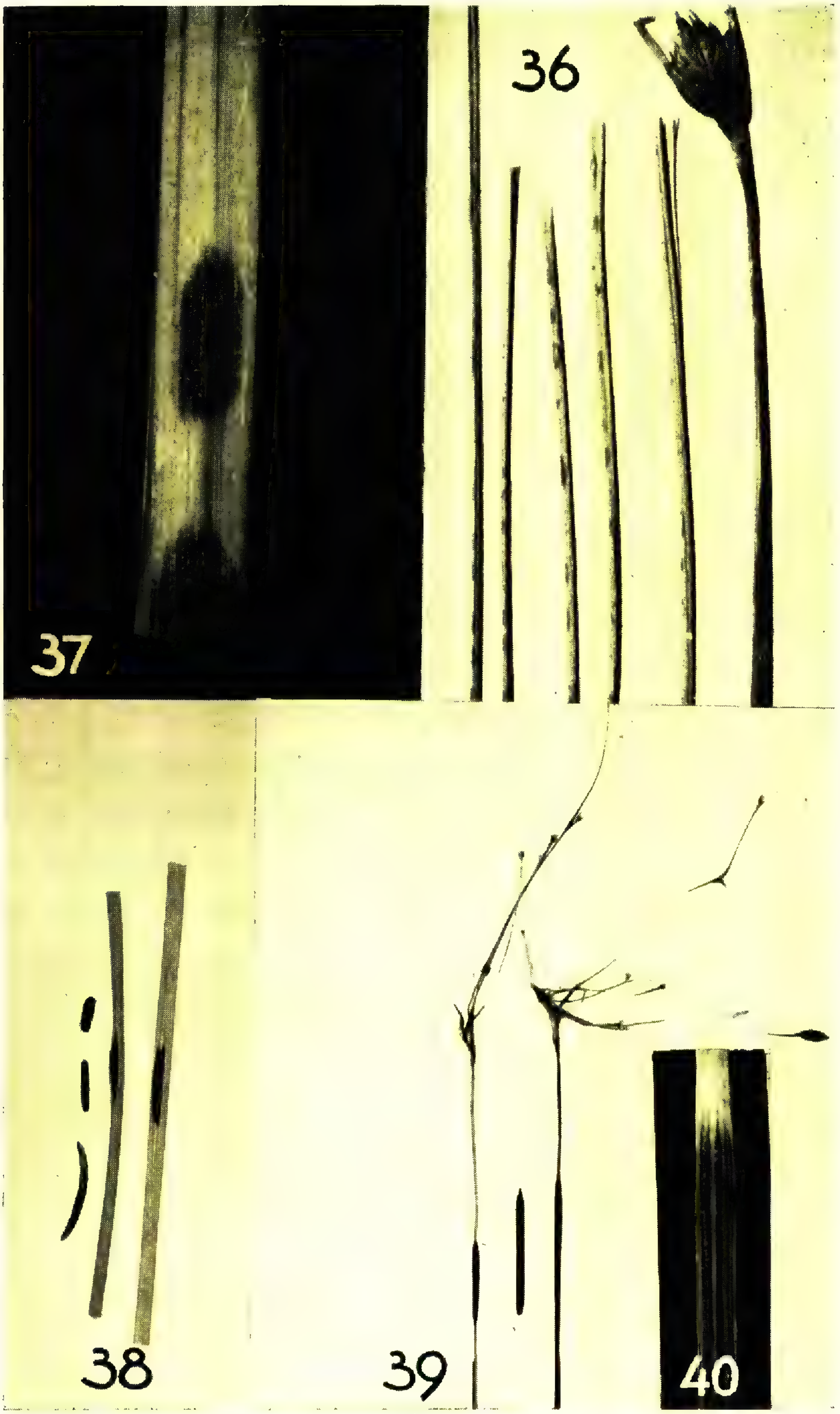


PLATE IX

species of *S. duriaeana*. The characters peculiar to *S. scirpicola* may, in part at least, be due to its adaptations to a different suscept.

While Mougeot is credited by Fries with having first applied the name *Sclerotium roseum* to the original collecton made by Kneiff, there is substantial evidence that Kneiff himself is the legitimate author of the name. Not only did Mougeot and Nestler credit Kneiff with this name on the label of their Stirp. Crypt. Vogeso-Rhen. *884* (1826), but also Kneiff and Hartmann, two years later, in distributing this sclerotial stage, in their Pl. Crypt. Badens *20*, credit the name to Kneiff. Subsequent writers in referring to this name are divided as to the legitimate author of it. Tulasne and others follow Fries, but most of them credit Kneiff with the name. Saccardo (1899: 1153) notes that the name "*Sclerotium Kneiffi*" is applied to this fungus by others ("Quibusdam"). I have been unable to locate any other reference to the fungus under this name.

Currey's assumption (1857) that "*Sclerotium roseum* Kneiff" is the sclerotial stage of "*Peziza curreyana*" was accepted by all subsequent students of *S. curreyana* until Rehm (1893) pointed out the error in the note to his description of *Sclerotinia scirpicola*. This confusion of the sclerotia in the culms of *Scirpus* with those in the culms of *Juncus* as representing one and the same species had not, however, escaped suspicion in the critical mind of Tulasne (1861: 105) who while admitting that the sclerotium in *Scirpus* ". . . seems to agree completely with it (in Juncus) in its whole structure though no one has yet found it in fruit" remarks "But we are sorry that it has not been possible for us to test it by suitable culture, for we have never seen it alive".

SCLEROTINIA SCHOENICOLA

PLATE IX, FIGS. 36–38

Desmazières appears to have been the only mycologist to refer to specimens of what proves to be a heretofore unrecognized species of *Sclerotinia*. He took the sclerotial and spermatial stages of this fungus on *Schoenus nigricans* (Figs. 36–38) to be the same as those on species of *Carex* which he designated respectively *Sclerotium sulcatum* and *Epidocium affine*, and which were later (1929) recognized by Whetzel as stages in the life cycle of *Sclerotinia sulcata*.

Desmazières [7] distributed specimens of the culms of *Carex vulpina* and *acuta* and culms of *Schoenus nigricans* all of which contained sclerotia very

[7] Plantes Cryptogames France, Ed. 1, Ser. I, No. *2029* (1850); Ed. 2, Ser. II, No. *1629* (1853).

Plate 9. *Sclerotinia schoenicola* and *S. luzulae*. **Fig. 36.** Culms of *Schoenus nigricans* showing spermodochidial patches, from Desmazières' Plantes Crypt. France, Ser. II, *21*; about natural size. **Fig. 37.** Spermodochidial areas, x6. **Fig. 38.** Sclerotia of *S. schoenicola* from culms of *Schoenus nigricans* from Desmazières' Plantes Crypt. France, Ed. 2, Ser. I, *1629*; natural size. **Fig. 39.** Culms of *Luzula pilosa* from Krieger's Fung. Sax. *2073* showing sclerotia of *Sclerotinia luzulae* (revived dry specimens); natural size. **Fig. 40.** Portions of a sclerotium still enclosed in the culm, x6.

similar in character (see Whetzel 1929: 7) and which he collectively labeled "Sclerotium sulcatum Rob. in herb." No date or locality is indicated on the packets. Presumably Roberge was the collector. In specimen *2029* the culms were all mixed together. In his formal description of *Sclerotium sulcatum*, Desmazières (1851) does not mention *Schoenus nigricans* specifically, saying only "hab. in culmis siccis Caricum"; but in the note following he says (transl.) "This fungus was found inside triangular stubble of *Carex vulpina* and *C. acuta* and in species with cylindrical culms", the last referring undoubtedly to *S. nigricans* which, in the later distributed specimens (number *1629*), were segregated into a separate packet and labeled *Schoenus nigricans*. His description clearly applies primarily to the sclerotia in the *Carex* culms, thus in effect leaving those in *S. nigricans* without a name.

Desmazières [8] later (1853) distributed the upper portions of the same culms containing the spermatial fruit bodies as those containing the sclerotia (Ed. 1, Ser. I, *2029*; Ed. 2, Ser. II, *1629*) distributed in 1850. Here, however, he separated the culms of *Schoenus* from those of *Carex* in different packets. In his description of the spermatial fruit bodies (1853) he gives these the name "Epidocium affine Desmaz." and gives both *Schoenus nigricans* and *Carex* species as suscepts citing his exsiccati specimens Series II, *21*. His description, however, clearly applies primarily to the fruit bodies on the *Carex* culms, thus again leaving those on *Schoenus* nameless.

The evidence clearly indicates that the sclerotia and the spermodochidia on *Schoenus nigricans* belong to the same fungus. The spermodochidial patches on the culms of *S. nigricans* are quite distinct in character from those of *E. affine* and from those of the other *Sclerotinia* species on the *Cyperaceae*. (Compare Figs. 36 and 37 with Figs. 11–14.) The sclerotia, while very similar to those of *S. sulcata*, are rather more slender but the spermodochidia are very different. Since the spermodochidia are taxonomically the most distinctive structures of the different species of *Sclerotinia* in this group, I have no hesitation in giving to this species a distinctive name.

It is perhaps remarkable that this species apparently has not been collected by mycologists since the days of Desmazières. It is probably not rare but will be found by one seeking it in the proper localities. I unfortunately encountered *Schoenus nigricans* in but one locality in Europe. That was in late summer on the fens at King's Lynn, England. No trace of the *Sclerotinia* was found.

This species is here presented, chiefly to bring it to the attention of European mycologists in the hope that someone will be stimulated again to discover this very interesting form and make a more complete study of its different stages. Only in this way may it be determined whether I am correct in assuming it to be distinct from other species occurring on members of the *Cyperaceae*. Our present scanty knowledge of this form is summarized in the following technical description.

[8] Plantes Cryptogames France, Ed. 3, Ser. II, No. *21* (1853).

SCLEROTINIA SCHOENICOLA, sp. nov.

Maculis spermodochidialibus majusculis, ovatis vel circularibus, numerosis, magnitudine variabilibus, 2–6 mm. in diametro, sub inflorescentiis infectis irregulariter secundum unum culmi latus dispositis, pallide olivaceo-brunneis coloris atroolivacei massae spermodochidiorum globosorum lurideque brunnei cellularum contextus suscipientis gratia; structura interna spermodochidiorum structurae *S. scirpicolae* subsimili; sclerotiis gracilibus, fusiformibus, apicibus obtusis instructis, strictis, rarius manifeste curvatis vel inaequilateralibus sclerotiorum *S. sulcatae* modo, initio pallide roseis, dein nigrescentibus ad superficiem, intus albis, fortiter arato-sulcatis, 8–10 x 1–2 mm. in statu sicco, per rimam culmi liberatis; apotheciis ignotis.

Spermodochidial patches (Figs. 36, 37) rather large, ovate to circular, numerous, variable in size, 2–6 mm. diam., distributed irregularly along one side of the cylindrical culm, just below the blighted head, pale olivaceous brown, due to the dark olivaceous color of the massed globose spermodochia and dead brown cells of the suscept tissues; internal structure essentially like that of the spermodochidia of *S. scirpicola.*

Sclerotia (Fig. 38) slender, fusiform, tips blunt, straight, rarely distinctly curved or inequilateral as are the sclerotia of *S. sulcata*, at first pale pink, becoming black externally, white within, strongly furrowed, 8–10 mm. long by 1–2 mm. thick (dry), discharged by a slit in the culm.

Apothecia unknown.

HABITAT: Culms of *Schoenus nigricans* L.

DISTRIBUTION: Apparently known only from France. There is nothing on the labels of Desmazières' specimens (the three cited above) to indicate where, when, and by whom they were collected. All were presumably from material sent him by Roberge.

TYPE SPECIMENS: Desm. Pl. Crypt. France. Ed. 1, Ser. I, *2029* (in part) (1850), and Ed. 2, Ser. II, *1629* (in part) (1853), (sclerotia only); Ed. 3, Ser. II, *21* (in part) (1853) (spermodochidia only).

SPECIMENS EXAMINED: The specimens from Desmazières' Plantes Cryptogames France listed above were examined in the Royal Herbarium at Kew and in the British Museum in London, in the New York Botanical Gardens, in the Farlow Herbarium, Cambridge, Mass., and in the Mycological Collections, Bur. Pl. Ind., U.S.D.A.

The life history of *S. schoenicola* is presumably similar to that of the other species of *Sclerotinia* attacking cyperaceous suscepts. Invasion is evidently by way of the flowers. The appearance of the spermodochidia might suggest a near relationship to *S. scirpicola,* while from the shape and size of the sclerotia one would rather infer that *S. schoenicola* is more nearly related to *S. duriaeana* or *S. sulcata.*

SPECIES ON THE JUNCACEAE

There are, as far as I have discovered, but three species of the true *Sclerotinias* attacking members of the Juncaceae. These are *S. curreyana,* very common in culms of *Juncus effusus* in Great Britain and western continental Europe; a species in our Pacific Northwest, described as *Ciboria juncigena*; and an undescribed species on *Luzula pilosa* known only from one collection taken in Saxony, Germany.

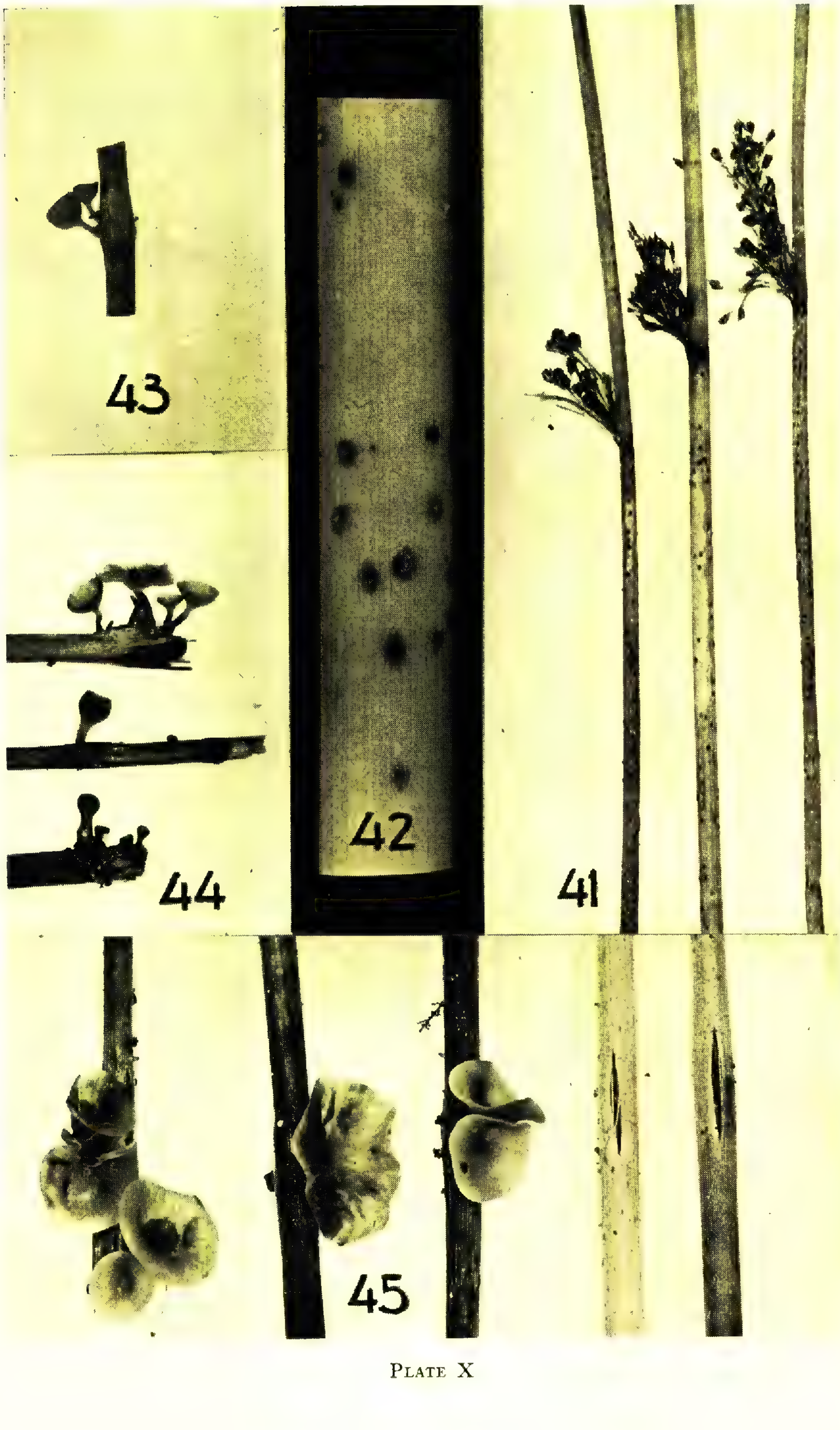


PLATE X

SCLEROTINIA CURREYANA

PLATE X AND TEXT FIG. D

Tulasne in 1861 in his Selecta Fungorum Carpologia (**1:** 104–105) described accurately and in some detail two species of *Sclerotinia* in the group under consideration in this paper, and in 1865 (**3:** pl. 22) presented beautiful illustrations of both.

Thus *S. curreyana* and *S. duriaeana* may well be regarded as the classical representatives of the species of *Sclerotinia* occurring on sedges and rushes. Of these two, *S. curreyana* has long been the best known to the English and European mycologists since the time of its study by Berkeley and Currey in 1857, because of its very common occurrence and the fact that the apothecia are readily found arising from the sclerotia of the still standing, bleached culms. There is strong circumstantial evidence, however, that it was really first described by Fries in 1818 under the name of *Peziza ciborioides*. Rehm (1893: 822) appears to have been the first to question whether *Peziza ciborioides* of Fries (1824), to which Persoon four years later (1822: 277) gave the new name *Peziza friesii*, may not have been the *Peziza curreyana* which Currey described in 1857. A careful consideration of all the evidence leads me to believe that Fries actually had this species on culms of *Juncus* in view when he named and described *P. ciborioides*. His description fits the species well, inadequate though it is. The fact that his fungus occurred in culms in early spring in marshy places is very suggestive if not confirmatory evidence for my opinion. However, since Fries' specimens are not preserved and since the fungus is so well known under the name suggested by Berkeley, I am not using the Friesian name which current rules of nomenclature might justify. I found this species very abundant in the region about London in the early spring of 1930 and so had an unusual opportunity to observe and study it. I have searched for it diligently since that time on *Juncus effusus* in the Cayuga Lake region of central New York, but have never found it, nor is it recorded from anywhere in North America, unless *S. juncigena* should prove to be conspecific. It should be found throughout the Euro-Asian continent wherever its suscepts occur.

SCLEROTINIA CURREYANA (Berk. *in* Currey) Karsten, Revisio Monogr. p. 123. 1885.

Peziza curreyana Berk. *in* Currey, Journ. Linn. Soc. **1:** 147. 1857.
Peziza curreyi Berk. Outlines Brit. Fung. p. 370. 1860.
Rutstroemia curreyana Karst. Myc. Fenn. **1:** 107. 1871.
Phialea curreyana (Bart.) Gillet, Discom. p. 211. 1879.
Sphacelia tenella Sacc. Miscellanea Mycologica *in* Venezia Ist. Atti, Ser. 6, **2:** 448. (Reprint **1:** 14) 1884. (See Saccardo 1886: 666.)

Plate 10. *Sclerotinia curreyana.* **Fig. 41.** Diseased culms of *Juncus effusus* showing spermodochidia; about natural size. CUPP *31655*. **Fig. 42.** Spermodochidia, x6. **Fig. 43.** Apothecia arising from sclerotia within standing culm; natural size. CUPP *15578*. **Fig. 44.** Apothecia in various stages of development from sclerotia in culms in moist chamber; natural size. CUPP *20198*. **Fig. 45.** Apothecia fully expanded; culms showing rupture slits over enclosed sclerotia, x2. CUPP *20198*.

Peziza juncifida Nylander, Pezizas Fenniae *in* Sällsk. Fauna et Fl. Fenn. Forhändl. Notiser (n. s. **7**) **10:** 39. 1869.
Hymenocypha curreyana Phill. Manual Brit. Discom. p. 16. 1887.
Placosphaeria junci Bubák, Ann. Myc. **4:** 113–114. 1906.
Sphacelia curreyana Grove, Journ. Bot. Brit. and Foreign **50:** 46. 1912.
Myrioconium tenellum V. Höhnel, Mitteil. Bot. Inst. Tech. Hochsch. Wien. **3:** 50. 1926.

Spermodochidia (Figs. 41, 42) numerous, scattered irregularly along and about the upper part of the diseased culms, usually most numerous along one-half of the circumference of the culm, minute, pustulate, ellipsoid, brown, slightly erumpent when fresh and moist, opening by a slit in the epidermis; *spermatia* minute, globose, 2–2.5 μ in diameter, produced from the tips of obclavate spermatophores fasciculately clustered about a centrum to form globose spermodochia as in other species of this group, but also forming an irregular hymenium lining the cavity.

Sclerotia one to several in each culm, short, stout, cylindric with blunt, rounded ends, 4–15 mm. or more long, by 2–4 mm. in diameter, externally black or dark brown, coarsely sulcate, internally white when mature, of a rosy pink color during development, embedded in the pithy interior of the culm, disclosing in section the inclusion here and there of remnants of undigested pith cells. The structure of the rind and medulla is essentially like that of the sclerotia of *S. scirpicola*. The sclerotia are not freed from the culms at maturity but remain embedded, apothecia developing in the spring from the surface exposed by a slit in the epidermis of the culm over the sclerotium.

Apothecia (Figs. 43–45) two to several from each sclerotium, short-stipitate, pale tan to dark avellaneous brown; *cup* thin, deep goblet-shaped to infundibuliform, often umbilicate, 2–12 mm. or more in diameter, margin entire, recurved, smooth without, rugose-fluted within; *stipe* as long as the diameter of the cup, equally cylindrical, flexuous, solid, glabrous or slightly hairy to tomentose at the base, somewhat darker in color than the cup; *asci* long, slender, clavate, apex rounded, 38 meas. gave 47.6–78 x 4–5.4 μ, mode 65 x 5.4 μ, av. 65.2 x 5 μ; 8-spored, spores uniseriate; *ascospores* slender, allantoid, ends rounded, 99 meas. gave 7.9–14.5 x 1.3–2.9 μ, mode 11 x 2.9 μ, av. 11.5 x 2.5 μ; *paraphyses* "slender, pale brown at the slightly thickened apex", according to Massee (1895: 282). I have found it impossible satisfactorily to make out the characters of the paraphyses from dry material.

In culture on potato dextrose agar this fungus makes a dense cottony, felty growth of pinkish aerial mycelium with eventual development therein of more or less globose sclerotia which are at first a bright pink, and finally form a white to pink medulla that is enclosed in an olivaceous brown rind. The olivaceous brown masses of sporodochia form about the margin of the mycelial mat.

HABITAT: In culms of *Juncus*, most common in *Juncus effusus* L. but recorded also on *J. conglomeratus* L., *J. glaucus* Ehrh., and *J. filiformis* L.

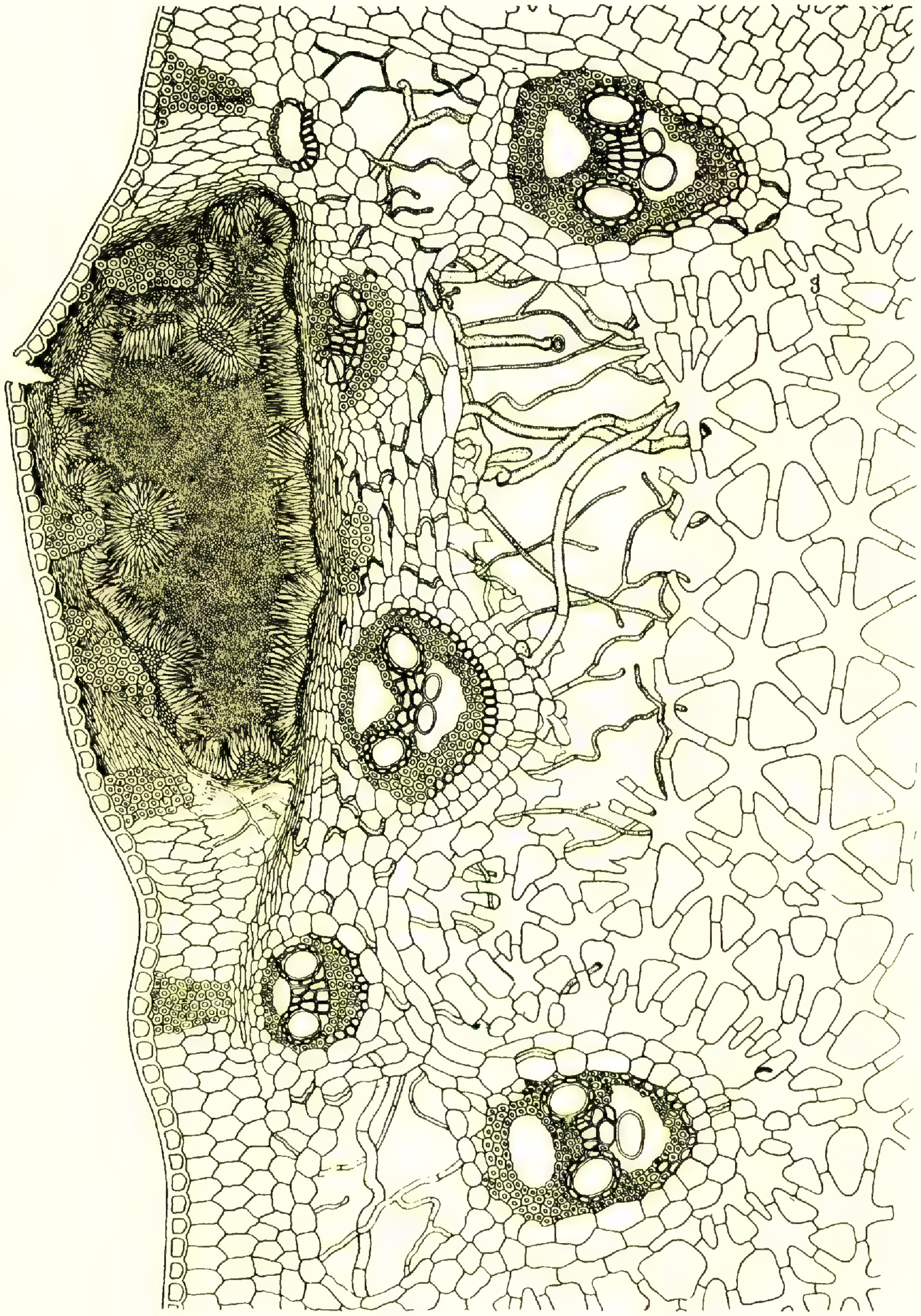
in wet locations, meadows, heaths, moors, and along ditches. The apothecia appear in early spring, followed by infection of the culms in which the spermatia and sclerotia appear during midsummer and early autumn.

DISTRIBUTION: This species appears to be most common in Great Britain judging from my own observations and from the numerous collections in herbaria. Known also from Belgium (Lambotte 1887: 303) and Bommer and Rousseau (1884: 133), France (Boudier 1905: 273–4) and Saccardo (1889: 199), Finland (Nylander 1869: 39), Denmark (Lind 1913: 109), Bohemia (Bubák 1906: 113, spermodochidia). Velenovsky (1934: 223) records this species in Bohemia on *Juncus glaucus* and *J. piscinam*, also in heads of wheat. His description and his figures would indicate that he had some species quite different from *S. curreyana*. The spores as he describes and figures them are certainly not the spores of this species.

TYPE SPECIMEN: There are a number of collections of this species deposited (in 1881) in the Royal Herbarium at Kew of which at least three packets are from Currey's personal herbarium and collected on "Paul's Cray Common, Near Chislehurst in Kent", the locality given by Currey (1857) as the place where, on the 23rd of April 1856, he first discovered the apothecia of *Peziza curreyana*. The label on these specimens says "On *Juncus conglomeratus*" and is dated "May, 1856". These specimens would, therefore, appear to constitute the type material. Massee (1895: 283) says that he had examined the type specimen.

MATERIAL EXAMINED: In addition to Currey's type specimens, I have carefully examined the other twelve specimens in the Kew Herbarium, all of which were apparently collected in England from 1856 to 1884. The labels for most of them are very sketchy. They appear to be mostly specimens collected by (or sent to) Currey and Berkeley. In the herbarium of the British Museum there is a sheet and a half of packets of this species, all originally in the collection of William Phillips. One specimen labeled "conidia" is of special interest, as showing that Phillips recognized the spermatial stage of *S. curreyana*. These all appear to have been collected in England.

In addition to the above, I have had for study the following: On **Juncus effusus** L.: CUPP *15578*, Worcester, England, October 18, 1926, *C. Rea* (sclerotia from which I developed apothecia the following April); — CUPP *31648*, Wisley, Surrey, England, February 10, 1930, *Whetzel, Green & Cotton* (apothecia); — CUPP *31654*, Goslar am Harz, Germany, Harzerberger Thal, *Whetzel & Westcott*, April 22, 1930 (apothecia); — CUPP *31655*, near Downton in Hampshire, England, August 2, 1930, *Whetzel & Brown* (spermodochidia); — CUPP *31657*, Sandhill bog, Worcestershire, England, August 9, 1930, *Whetzel & Rea* (spermodochidia and sclerotia). On **Juncus conglomeratus** L.: CUPP *31658*, shore of Loch Katrine near Stronachlar Pier, Scotland, August 3, 1930, *Mrs. Whetzel & Miss Westcott* (spermodochidia); — CUPP *31659*, near Plowright's old home, not far from King's Lynn, England, *Whetzel* (spermodochidia); — CUPP *20198*, Phytopathological Field Station, Slough, Buckingham, England, December 5, 1931, *Mr. and Mrs. E. W. Mason* (sclerotia from which I developed apothecia in April at Ithaca, New York); — CUPP *31662*, near London, England, May 1934, *William Brown* (sclerotia); — Otto Jaap, Fungi Selecti Exs. *754 a* and *b*. Prov. Brandenburg, Triglitz in Prignitz, *O. Jaap*. (a) apothecia, May 30, 1916. (b) spermodochidia, "Placosphaeria junci", *Bubák*, November 3, 1915; — CUPP *31656*, near Downton, Hampshire, England, August 2, 1930, *Whetzel & William Brown* (spermodochidia); — Sydow, Mycotheca germanica *2358*, near Burgholdinghausen, Kreis Siegen, Westfalen, Germany, May 18, 1924, *A. Ludwig* (apothecia).



TEXT FIG. D

This species is also said to occur on *Juncus glaucus* Ehrh., on *J. filiformis* L. and on *J. communis* E. May. Saccardo (1886: 666) described the spermatial stage under the name *Sphacelia tenella* from a collection on *Juncus glaucus* collected near Rouen, France. Mr. Carleton Rea (in a letter April 24, 1927) says the sclerotia of *S. curreyana* are common in the culms of this species in the vicinity of Worcester, England. Bubák (1906: 113) described what is apparently the spermatial stage of our fungus under the name *Placosphaeria junci* in culms of *Juncus filiformis* and Nylander (1869) has described the apothecial stage under the name *Peziza juncifida* on culms of *Juncus* (*compressi*?) but I have not seen material on any of these suscepts.

In numerous records of collections of this fungus, the species of *Juncus* on which it occurred is not given. The evidence available seems to indicate very clearly that *S. curreyana* is most frequently to be found on *Juncus effusus* L. and *Juncus conglomeratus* L.

The erroneous identification of the sclerotial stage of *S. curreyana* with that of *S. scirpicola* by Currey and Berkeley has resulted in the citation of *Sclerotium roseum* in many synonymies of *S. curreyana* (See p. 413). In his transfer of *Peziza curreyana* to the genus *Phialea*, Gillet writes "Bart." for the author of the species. This appears to be an error for "Berk." The inclusion of *Peziza juncifida* Nyl. and *Placosphaeria junci* Bubák in the synonymy of this species might be questioned, since I have not been able to see authentic specimens of either. Nylander's description of *P. juncifida*, while brief, appears to me to justify the conclusion that he had apothecia of *S. curreyana* in hand.

There would appear to be little question of the identity of Bubák's fungus with the spermatial stage of *S. curreyana*, since his sketch of a section through the fruit body is quite in character with the spermodochidium of this Discomycete (See Text Fig. D.) Bubák records his fungus on *Juncus filiformis*, a species on which this Discomycete is not otherwise known to occur.

The slender curved ascospores of *S. curreyana* are strikingly different from the ascospores of any of the other species in the genus. The structure of the spermodochidium is also different from that of the others. The dark color is due in part to the dilute brownish color of the central hyphae of the spermodochidia and brown hyphae in the covering epidermal cells. It is, however, largely the result of the dark brown discoloration of the crushed thin-walled cells of the parenchyma surrounding the spermodochidial cavity giving the appearance of a spermogonial wall. This "wall" is further suggestive of a true hyphal wall, since resting upon it is a spermatophore hymenium, lining the cavity (Text Fig. D). This hymenial lining presents a picture very different from that in the spermodochidia of the species in *Carex* suscepts, where it is entirely wanting. However, just as in the *Carex*-

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Text Fig. D. Cross section through a spermodochidium of *Sclerotinia curreyana* about x200. Note that the cavity is formed by extensive lysis of the parenchyma between the vascular bundles with collapse and browning of the surrounding cells to form a pseudo-spermogonial wall. Drawn by Carlos Garcés.

invading species, *S. curreyana* also produces globose spermodochidia which lie typically in the central cavity of the hymenium-lined spermodochidium. These peculiarities might be taken to indicate that it is not closely related to the other species in the group here under consideration, but in all its other characters it conforms very closely. Its nearest relationship would seem to be with *S. scirpicola* if one considers the similarity of the sclerotia of these two species.

In culture on potato dextrose agar *S. curreyana* presents a picture strikingly like that of *S. sulcata*, the chief difference being the pinker hue of the mycelial mat of the former. Both form sclerotia on this medium and the medulla of the sclerotium of *S. sulcata* is nearly as pink as that of *S. curreyana* at comparable stages in its development.

It is remarkable in the light of Tulasne's recognition (1861: 104) of the spermatial stage in *S. duriaeana* that the spermatial stage of *S. curreyana* was not described until 1884 (Saccardo) and not recognized as such until 1912 (Grove). Grove says the spermatia measure 3–5 μ in diameter. Presumably his measurements were made from fresh material. Mine (2–2.5 μ) were made under oil immersion from dry material soaked over night in weak KOH. This difference in size is, however, hard to explain on these grounds.

SCLEROTINIA JUNCIGENA

In May 1883, Suksdorf collected the apothecial stage of a little Discomycete apparently growing on the surface of "dead stems of *Juncus* above the water in Falcon Valley", according to a note on the packets distributed by him in his exsiccati, Flora of Washington. Ellis, who determined the material, gave it the name *Ciboria juncigena* E. & E. Dr. J. R. Keinholz advises me in a letter of June 7, 1942 that the name "Falcon Valley" apparently was abandoned many years ago and the name changed to "Hell Roaring Meadows", which lies at the head of a creek of the same name. No other collections of this form have been preserved as far as I can discover, although Dr. S. M. Zeller of the Oregon Experiment Station writes me that he has once come upon this fungus in the field. The species of *Juncus* is not given by Suksdorf but it is probably *J. effusus* var. *pacificus* Fern. & Wiegand. Dr. Keinholz who kindly undertook to locate fresh material of this fungus has thus far been unsuccessful. Its close resemblance to *S. curreyana* of Europe makes a critical study of living specimens highly desirable. Pending such a study it seems wisest to retain its present specific standing.

SCLEROTINIA JUNCIGENA (E. & E.) n. comb.

Ciboria juncigena E. & E., Proc. Acad. Nat. Sci. Phila., Nov. 30, 1894, p. 348.

Spermodochidia not seen.

Sclerotia one, possibly more, within a diseased culm, slender, cylindric, with truncate, slightly rounded ends, up to 15 mm. long by 2 mm. in diameter, externally black, finely sulcate, internally white when mature; apparently lying free in a lysigenous cavity in the pith region of the culm; structure essentially like that of *S. curreyana*. The sclerotia are not freed from

the culm at maturity, nor are they apparently exposed by a slit on emergence of the apothecia as in *S. curreyana*.

Apothecia usually but one from each sclerotium, long-stipitate, avellaneous (?); *cup* thin, membranous, shallow cup-shaped, sub-umbilicate, 4–5 mm. in diameter; *hymenium* "wine colored"; *stipe* arising from the sclerotium within and penetrating the wall of the culm, relatively long, about 1 cm. by 1 mm. thick, lower half or more black, longitudinally wrinkled, fibrillose, anchored at point of emergence to the surface of the culm by a spreading dark hyphal mat, concolorous above with the cup; *asci* clavate-cylindrical, (Ellis meas.) about 60 x 4–5 μ, 8-spored, spores sub-biseriate; *ascospores* allantoid, slender, distinctly curved, hyaline, (Ellis meas.) 7–8 x 1.25 μ, (Whetzel, 50 meas. in KOH) 7.2–10.8 x 1.2–2.4 μ, mode 8.4 x 2.4 μ, average 8.86 x 1.83 μ; *paraphyses* not distinguishable in mounts from dried material.

HABITAT: In culms of *Juncus* (probably *J. effusus* L. var. *californicus* Fern. & Wiegand) in wet marshes. The apothecia appear in May on standing dead culms.

DISTRIBUTION: Known only from the type locality. Falcon Valley (now Hell Roaring Meadows), Washington State.

TYPE SPECIMEN: Exsiccati specimens distributed as *371* Flora of Washington. Collected by W. N. Suksdorf, May 31, 1883. I have seen two packets, one deposited from the Ellis Collection in the N. Y. Bot. Gard. herbarium and another in the Mycol. Coll. Bur. Pl. Ind., Washington, D. C.

It is with some hesitation that I treat *Ciboria juncigena* E. & E. as a species distinct from *S. curreyana*. It is undoubtedly a *Sclerotinia* rather than a *Ciboria*. Ellis entirely overlooked the presence of the sclerotia, which was perhaps due to the absence of a slit in the culm over the sclerotium and the unusual anchorage of the stipe to the surface of the culm. As far as the characters of the cup are concerned, it could hardly be distinguished from *S. curreyana*, but the long, slender stipe, its black color, and the basal, dark hyphal mat anchoring it to the culm at the point of emergence, together with the slender character of the sclerotium, may well prove to be dependable evidence of its specific character. It is unquestionably very closely related to *S. curreyana* and may indeed be more properly regarded as an American form of variety of that species. However, my experience with the closely related *S. duriaeana* and *S. sulcata*, together with the fact of its long geographical isolation from the ancestral *S. curreyana*, inclines me to believe that a fuller study of *S. juncigena* in fresh condition and in its spermatial stage will prove it to be a distinct species.

SPECIES ON LUZULA

SCLEROTINIA LUZULAE

PLATE IX, FIGS. 39 AND 40

W. Krieger distributed in his Fungi Saxonici *2073* culms of *Luzula pilosa* L. in which are embedded slender black sclerotia of a fungus which he

labeled provisionally "*?Sclerotinia Curreyana* (Berk.) Karst." The label bears a brief description of the sclerotia with the remark that unfortunately he had been unable to develop the fruit body of the Ascomycete, hence the question mark before the name he was giving the specimen. He apparently collected the specimens he distributed under this number in two different localities and in different years, in Polenztale, Utterwaldergrunde, late May 1896, and near Königstein, June 1897. In Rehm's collections at Stockholm, Sweden, there is in addition to Krieger's exsiccati specimen *2073*, another packet labeled in Krieger's handwriting bearing the same data, evidently duplicate material.

I have been able to locate but one other collection which is in the herbarium of the Mycological Collections, Bur. Pl. Ind., U. S. D. A., Washington, D. C. This bears the label "Herbarium G. Bresadola, *221* Sclerotium roseum Moug. en feo oritur Scler. Curreyana Berk. Sclerotium Luzulae Krieg. n. sp.? In den dürren Halmen von Luzula pilosa Willd. bei Königstein, 19. Juli, 1897. Lg. W. Krieger". The name "*Sclerotium luzulae* Krieg." appears never to have been published. The specimen is apparently a part of the 1897 collection distributed by Krieger in his Fungi Saxonici *2073*. Krieger's collections of a sclerotial form on *Luzula pilosa* would seem, for the present, best regarded as a distinct species.

SCLEROTINIA LUZULAE sp. nov.

Spermodochidiis apparenter nullis; sclerotiis 1–3 vel pluribus, intra culmos natis et maturitate ad superficiem soli ruptionis culmorum causa liberatis, 5–30 x 1 mm., fusiformibus, acute abrupteque acuminatis unum ad latus, aqua imbutis obscure castaneis, siccis nigris, indistincte arato-sulcatis, cortice uno e strato cellularum atro-tunictarum consistente, medulla alba, ex hyphis dense compactis, multo minoribus diametro ordinario specierum stirpis huius composita; apotheciis ignotis.

Spermodochidia apparently wanting.

Sclerotia one to three or more formed within the culms which are ruptured at maturity, discharging the sclerotia onto the soil, 5–30 mm. long by 1 mm. in diameter, fusiform, sharply and abruptly pointed at either end, dark mahogany brown when soaked in water, black when dry, indistinctly furrowed, not sulcate as in other species in this group, rind one layer of dark-walled cells, medulla white, composed of densely packed hyphae which are much smaller in diameter than those of the sclerotia of other species in this group.

Apothecia unknown.

HABITAT: In culms of *Luzula pilosa* Willd. in Saxony, Germany.

DISTRIBUTION: Known only from the type locality and very rare, according to the collector.

TYPE SPECIMEN: Krieger's Fungi Saxonici *2073*, in culms of *Luzula pilosa* Willd. in Polenztale, Utterwaldergrunde, May 1896 and near Königstein, June 1897, *W. Krieger*.

MATERIAL EXAMINED: I have carefully examined the specimens of the type collections in the British Museum and in the CUPP Herbarium; also the specimen from the herbarium of the Bur. Pl. Ind., U.S.D.A.

Krieger, on the label of his Fungi Saxonici *2073*, refers the specimen provisionally to *Sclerotinia curreyana* and cites *Sclerotium roseum* Fr. as a synonym, obviously two errors. This species is probably more common than Krieger surmises and should be sought wherever the suscept occurs.

The apparently complete absence of spermatial fruit bodies is puzzling. I have scrutinized carefully all the culms which I find in Krieger's collections but without finding any trace of spermodochidia. Their absence is most unusual, this being the only species in this group, except *S. vahliana* and *S. juncigena*, in which I have not found them. That I should have found them in these two species is almost certain had I had specimens of diseased culms collected during the summer.

EXCLUDED SPECIES

Several species of stromatic Discomycetes other than those described above occurring on species of the *Cyperaceae* and *Juncaceae* have been put in the genus *Sclerotinia* by various authors. None of these species with which I am acquainted are, however, congeneric with the true species of *Sclerotinia* as I interpret that genus. I list them here with some observations and comments which may prove useful to my mycological colleagues until such time as I may treat them more fully.

Sclerotinia aschersoniana P. Henn. & Plöttn. Verh. Bot. Vereins, Prov. Brandenburg **41:** IX, 1899.

This species is pathogenic in the ovaries of certain species of *Carex*, notably in *C. hudsonii* A. Bennet (=*C. stricta* Good.) in Europe and on *C. stricta* Lam. in North America. I have collected and cultured it frequently from the latter species in swamps in central New York and once from *C. prairea* Dewey in the same region. It is certainly not a *Sclerotinia*. It infects the suscept by ascospore invasion through the stigma, converting the ovary into a black stromatized mummy. It might be referred to the genus *Ciboria* but its proper taxonomic relationships require further consideration.

Sclerotinia utriculorum Boud. Bull. Soc. Myc. France **19:** 196–197, *pl. 8, fig. 6*. 1903.

This is described as growing on the hard seeds of *Carex davalliana* in May, in the Jura in France. Boudier says it differs from other species of *Sclerotinia* on *Carex* in that the apothecia do not arise from sclerotia but from the sclerified achenes of the *Carex*. As he makes no reference to *S. aschersoniana* it is probable he was unaware of that species. As far as I can judge, *S. utriculorum* Boud. is specifically the same as *S. aschersoniana* P. Henn. & Plöttn. Velenovsky (1934: 224) apparently regards this species as identical with *S. aschersoniana*, citing the latter as a synonym of *S. utriculorum*, but his reason for this is not clear.

Sclerotinia vesicariae Giesenhagen, Ber. Bayer. Gesell. Erforsch. der Heim. Flora **11:** 167–169. 1907.

This species is said to occur among ("inter") fallen dead seed of *Carex vesicariae* in autumn, collected by Stechsee near Seehaupt, Bavaria. The sclerotia are said to be irregularly cylindrical, rough, black, white within, 5–8 mm. long by 2 mm. in diameter. This would seem to indicate that this species does not occur in the ovaries of the *Carex*, but there is little else to indicate that it is distinct from *S. aschersoniana*. The asci are said to be 180–190 μ, considerably longer than those of *S. aschersoniana* which are given as 90–110 μ in the original description; the width is about the same. Ascus measurements, however, are so very variable in the stromatic Discomycetes, especially the length, as to be of little specific significance. The size and shape of the spores approximates those of *S. aschersoniana*. I am inclined to regard *S. vesicariae* as specifically distinct.

Sclerotinia caricina Velenovsky, Monog. Discom. Bohemiae **1:** 224; **2:** *pl. 22, fig. 40.* 1934.

This species is said to occur on the roots of *Carex muricata* among *Juncus communis*. It is not possible to tell from Velenovsky's description and figure whether this is a true *Sclerotinia* or not.

Sclerotinia paludosa Davidson & Cash, Mycologia **25:** 271. 1933.

A critical examination of all the specimens on which this species is based, discloses that the sclerotia shown in their *fig. 7* are those of a *Typhula*. The apothecia in the other specimens do not arise from sclerotia but from stromatized leaf tissues. This fungus is undoubtedly a *Rutstroemia*. It is a common species of wide distribution occurring on leaves and culms of various species of sedges, grasses, etc. The proper species name remains to be determined. It is probably conspecific with the following species.

Sclerotinia heterocarpa Bennett, Ann. Appl. Biol. **24:** 254. 1937.

While this species is described as occurring on grasses as the cause of the "dollar-spot" of turf, what is without doubt the same species has been discovered by the writer on leaves of *Carex* and several other plants. It was earlier described under the name *Ciboria armeriae* by Von Höhnel (Frag. Myk. *22*, Mitt. No. 1122, p. 43. 1918). This fungus is clearly not a *Sclerotinia*. It is without doubt a species of *Rutstroemia*.

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LITERATURE CITED

References cited in the text but not in the following list will be found in the synonymy of the species referred to.

Bommer, E. & M. Rousseau. *P. curreiana* Tul. *In* Florule mycologique des Environs de Bruxelles. Mem. Soc. Roy. Bot. Belg. **23:** 133. 1884.

Boudier, E. Icones Mycologicae **1–4.** 1905–1910.

Drayton, F. L. The sexual mechanism of Sclerotinia gladioli. Mycologia **26:** 48–72. 1934.

Ferdinandsen, C. & O. Winge. Studier over en hidtil upaaagtet, almindelig dansk Baegersvamp, Sclerotinia scirpicola Rehm. Biol. Arbejder Tilegnede, Eug. Warming den 3. November 1911: 281–298. 1911.

———. Über Myrioconium Scirpi Syd. Ann. Myc. **11:** 21–24. 1913.

Fries, E. *Peziza ciborioides. In* Observationes Mycologicae **2:** 307. 1824.

Groh, Herbert. A new host for Claviceps. Mycologia **3:** 37–38. 1911.

Höhnel, F. von, Über Epidocium affine Desmazières. Mitt. Bot. Inst. u. Tech. Hochsch. Wien **3:** 50–51. 1926a.

———. Über Placosphaeria Junci Bubák. Mitt. Bot. Inst. u. Tech. Hochsch. Wien **3:** 49–50. 1926b.

Lambotte, E. *Scler*[*otinia*] *curreiana* Tul. *In* Fl. Myc. Belg. Suppl. 1, p. (303). 1887.

Larsen, P. 324 *S. Vahliana* Rostrup, Grönl. Svampe 1891, p. 607. *In* Fungi of Iceland. *In* Rosenvinge & Warming, The Botany of Iceland **2**[3]: 504. 1932.

Lind, J. *Sclerotinia Curreyana* (Berk.) Karsten. *In* Danish Fungi as represented in the Herbarium of E. Rostrup, p. 108–109. 1913.

Massee, G. *Sclerotinia Curreyana. In* British Fungus-Flora **4:** 282–283. 1895.

Persoon, C. H. *(Peziza) Friesii. In* Mycologia Europaea **1:** 277. 1822.

Rostrup, E. *Sclerotinia Vahliana* Rostr. *In* Islands Svampe. Bot. Tidskr. **25**[3]: 315. 1903.

———. Fungi collected by H. G. Simmons on the 2nd Norwegian Polar Expedition, 1898–1902. *In* Rept. Second Norwegian Arctic Exped. in the "Fram" 1898, **9:** 5. 1906.

Saccardo, P. *Sclerotium nigricans* (Tul.) Sacc. *In* Syll. Fung. **14:** 1153. 1899.

———. *Sclerotinia Curreyana* (Berk.) Karst. *In* Syll. Fung. **8:** 198–199. 1889.

Tulasne, L. R. & C. Tulasne. Selecta Fungorum Carpologia **1:** 103–105. 1861; **3:** 203, pl. 22. 1865. (Transl. by W. B. Grove **1:** 106–108. 1931; **3:** 202, pl. 22. 1931).

Velenovsky, J. Monographia Discomycetum Bohemiae **1:** 1–436; **2:** *pl. 1–31.* 1934.

Whetzel, H. H. North American species of Sclerotinia II. Two species on Carex, S. duriaeana (Tul.) Rehm, and S. longisclerotialis n. sp. Mycologia **21:** 5–32. 1929.

———. The spermodochidium, an unusual type of spermatial fruit-body in the Ascomycetes. Mycologia **35:** 335–338. 1943.

———. Saccardo's confusion of the spermatial stage of S. duriaeana and S. curreyana with the sphacelia stage of Claviceps nigricans. Mycologia **36:** 426–428. 1944.

Whetzel, H. H. & W. G. Solheim. Sclerotinia caricis-ampullaceae, a remarkable subarctic species. Mycologia **35:** 385–398. 1943.

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JOURNAL OF MYCOLOGY. vol. 5, nos. 2, 3, 1889; vol. 6, 1890–91; vol. 7, 1891–94. Unbound. The lot **7.50**

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A Journal of Cryptogamic Botany

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CONTENTS OF VOL. 2, NO. 4

THE GENUS GRIFFITHSIA (Rhodophyceae) IN HAWAII. By *Isabella A. Abbott* . . 439

FUNGI DOMINGENSES NOVI VEL MINUS COGNITI. I. By *Carlos E. Chardon* . . . 455

THE BIOLOGY OF GYMNOSPORANGIUM NIDUS-AVIS THAXTER. By *Alton E. Prince* . 475

THE BOLETINEAE OF FLORIDA WITH NOTES ON EXTRALIMITAL SPECIES IV. THE LAMELLATE FAMILIES (Gomphidiaceae, Paxillaceae, and Jugasporaceae). By *Rolf Singer* 527

INDEX TO VOLUME 2 569

Vol. 2, No. 3 was issued on January 16, 1946.

FARLOWIA

A JOURNAL OF CRYPTOGAMIC BOTANY

VOL. 2 JULY, 1946 No. 4

THE GENUS GRIFFITHSIA (RHODOPHYCEAE) IN HAWAII

ISABELLA A. ABBOTT

The small, inconspicuous plants of the genus *Griffithsia* (Ceramiaceae, Rhodophyceae) are usually missed in general collections of algae. For the most part they are microscopic as well as epiphytic and occur well-mixed with other algae. In the subtropical waters of the Hawaiian Islands, members of this genus are usually found in reef and rocky shore habitats. They do not occur in abundance.

Griffithsia is fairly well known from the Atlantic and Indian Oceans, Caribbean and China Seas, and little known from the Pacific. The first record of the genus in the Hawaiian group was made by Reed in 1907, with reference to the economic use of the plants by the native Hawaiians. The algae are one of nearly seventy which were used to supplement the diet of the Hawaiians. Some of the more common native names of members of this genus are limu (literally translated as edible algae) moopuna-a-ka-lipoa, and limu aupuu. The native names of this and other algae vary from island to island, and sometimes on a single island.

Reinbold (1907) has listed *Griffithsia thyrsigera* (= *G. tenuis*) from Hawaii. MacCaughey (1917) and Neal (1930) have mentioned *Griffithsia ovalis* Harvey as possibly being present in the Hawaiian Islands.

Five species of *Griffithsia* are recorded here from the Hawaiian group. Four are listed for the first time from the area, and the presence of *G. ovalis* is confirmed.

New extensions of ranges are listed for *Griffithsia Binderiana* Sonder, an Australian species, *G. tenuis* C. Agardh, a cosmopolitan species, *G. Metcalfii* Tseng, reported from China, *G. ovalis* Harvey from Australia, and *G. rhizophora* Grunow from Ceylon, China, and the Malay Archipelago.

Cystocarps of *Griffithsia tenuis* and *G. Binderiana* are studied for the first time.

The following key is based on characters which are present for the greater part of the life history of the plants in the Hawaiian Islands. Cystocarpic and spermatangial plants which furnish the best differences among the species are infrequently found.

KEY TO THE SPECIES

A. Tetraspores between the articulations of the vegetative cells

B. Involucre surrounding tetraspores arising from vegetative cells; cells microscopic, subcylindrical below, globose at tips ..... **1. G. ovalis.**

B. Involucre attached to tetraspore pedicel; vegetative cells macroscopic and moniliform throughout ..... **2. G. Metcalfii.**

A. Tetraspores borne on specialized branches, or at the tips of the filaments

C. Cells cylindrical, slender; all reproductive structures formed on lateral pedicels ..... **3. G. tenuis.**

C. Cells subcylindrical or globose

D. Reproductive structures in lateral, specialized branches, all involucrate ..... **4. G. Binderiana.**

D. Tetraspores (other plants not seen) at the tips of globose cells; no involucre formed ..... **5. G. rhizophora.**

1. Griffithsia ovalis Harvey, Phycologia Australica **4**:203. 1862.

PLATE I, FIGS. 1–4; PLATE II, FIGS. 1–2

Plants in well-formed tufts to 2 cm. in height, or creeping on other algae and having erect filaments. Cells at the tips are oval to globular, 50–100 μ in diameter. Cells directly below are moniliform to subspherical, and at the base are larger and subcylindrical to ellipsoidal, 500–700 μ in diameter. Branches are occasionally fastigiate but predominantly dichotomous, with the tips slightly convergent. Rhizoids are commonly found throughout the plants which creep.

Tetrasporangia are borne between the articulations of the cells toward the tip, and are pedicellate with four or more sporangia on a pedicel. The mature tetrasporangia are about 40 μ in diameter. A slightly incurved involucre of 12–16 cells surrounds the tetraspores. No male or female plants have been collected.

Type locality: King George's Sound, Western Australia.

Distribution: Recorded previously only from Australia, and here recorded from the Hawaiian Islands.

Hawaiian specimens examined: **Oahu Island:** Kawela Bay, *Abbott 770b*, sterile on *Mesotrema*; Waimanalo, north of Makapuu Point, *Abbott 911a*, sterile on *Laurencia*; Diamond Head, below lighthouse, *Abbott 899a*, tetrasporic on *Halimeda*, *Abbott 900*, sterile on *Dictyosphaeria*; Waikiki, near marine laboratory, *Abbott 396*, *474*, *492*, *501* on *Sargassum*, *Abbott 502*, *504*, all tetrasporic.

The plants seem to be members of the *Griffithsia rhizophora-Schousboei-coacta* complex, and although they have many vegetative characteristics in common, studies of the male and female plants would be greatly desired.

Except for the small size of *G. ovalis*, the Hawaiian specimens also seem related to *Griffithsia corallinoides* (L.) Batters (*G. corallina* (Lightf.) C. Ag.). The involucrate tetrasporangial groups at the articulations are characteristic of both species.

The specimens have been collected on volcanic rock as well as on coral where they are much entangled with other small algae, chiefly *Centroceras clavulatum* (C. Ag.) Montagne and *Falkenbergia rufalanosa* Harvey. Although these collections have been made at different times of the year, only tetrasporic plants have been found.

2. Griffithsia Metcalfii Tseng, Papers Mich. Acad. Sci. Arts and Letters, **27**:111–116. 1942.

PLATE II, FIGS. 3–6

Plant caespitose, to 5 cm. in height, the fronds free at the outer ends, subdichotomous in the upper parts of the filaments. Cells are conspicuously moniliform, spherical, 500–700 μ in the terminal cells, largest in diameter through the center of the filaments, and subspherical to subcylindrical basally. Attachment is by large, stout, basal rhizoids. Tenacular cells often connect branches near the base of the plant with each other. Hair clusters are present in young specimens, and are quickly deciduous.

Spermatangial clusters are crowded between fertile vegetative cells below the terminal ends of the branches, and are not involucrate. Tetrasporangia bear a few involucre cells on the common pedicel. No cystocarpic specimens were collected.

Type specimen: C. K. Tseng 938 in the herbarium of Tseng, from Yenkehai, Hainan Island.

Hawaiian specimens examined: **Oahu Island:** Laie Bay at Makahoa Point, *Abbott 25*, tetrasporic, *Abbott 662*, spermatangial; *Richard Cowan*, 3 specimens from Nanakuli, tetrasporic; *Edna Fassoth*, from Waimanalo, sterile; *Reed*, without number, date, or locality, sterile.

This species compares very favorably with the type specimen. It is usually found with corallines in wave-swept areas about the Island of Oahu. The familiar *Griffithsia globulifera* Harvey of the Atlantic is related vegetatively to this species, but differs in branching and location of spermatangia. *Griffithsia rhizophora* Grunow of the Malayasian-Chinese coasts resembles *G. Metcalfii*, but is a smaller plant and has branches consistently convergent at the tips.

3. Griffithsia tenuis C. Agardh, Species Algarum **2**(1):131. 1828.

Griffithsia thyrsigera (Thwaites) Askenasy, Algae, *in* Forschungsreise S.M.S.Gazelle **4**:36, *pl.* 9, *figs.* 1–4. 1889.

Griffithsia sp. Neal, Hawaiian Marine Algae, Bishop Museum Bull. **67**:73–74. 1930.

PLATE III, FIGS. 1–7

Plant in freely branching loose tufts to 5 cm. in height, or prostrate and creeping on other algae. The multinucleate filaments are irregularly dichotomous, narrow in aspect, and non-forcipate. In the Hawaiian specimens, subsecund branches rarely occur and thus this character, so prominent in specimens from the Caribbean and China areas, is not a good one here. Cells of the filaments are cylindrical to subcylindrical, 60–80 μ in diameter, becoming smaller at the tips where they are surrounded by two or more clusters of hairs, the lower one long and six or more times dichotomous, the upper one short and quickly deciduous.

The asexual plants are usually found to be separate from the sexual plants, but in one collection tetraspores are found on the same plant as the cystocarps (*Abbott 472*). Tetraspores occur in whorls of 4–12 at the nodes of the upper filaments, each on a clavate or pyriform pedicel. Deciduous involucral cells infrequently surround the tetraspores of the Hawaiian specimens.

Cystocarps are lateral on a one-celled pedicel, surrounded by an involucre of 12–16 cells. The auxiliary cell of the carpogonium is cut off by the supporting cell as reported for *G. corallina* by Kylin (1916), and *G. Metcalfii* by Tseng (1942). Carpospores are formed by the repeated division of the auxiliary cell on its outer face. They are pyriform and are massed. Spermatangia are stalked, subcapitate, subglobose, without involucre, on lateral specialized branches.

Type locality: Venice.

Distribution: Widely distributed in warm to subtropical waters; in the Pacific area at points on the China coast, Fiji, and at Tutuila Island, Samoa.

Hawaiian specimens examined: **Oahu Island:** Laie Bay, *Abbott 485*, sterile; *Abbott 486*, tetrasporic; Waimanalo, 3 miles north of Makapuu Point, *Abbott 907a* on *Dictyota*, tetrasporic; Halona, *Abbott 300*, on *Microdictyon Setchellianum*, tetrasporic; Hanauma Bay, *Abbott 50*, tetrasporic, spermatangial; Wailupe, east of fishpond, *Abbott 808a* on *Dictyota*, sterile; Kaalawai, *Abbott 642*, on *Sargassum echinocarpum*, tetrasporic; Waikiki near marine laboratory, *Abbott 472*, tetrasporic and cystocarpic; *Abbott 491*, spermatangial, cystocarpic, tetrasporic; *Neal 23*, carpogonial, tetrasporic; Diamond Head, below lighthouse, *Abbott 839*, sterile, *Abbott 896a* on *Dictyota*, sterile, *Abbott 897a* on *Liagora*, tetrasporic; *G. P. Andrews* without collecting data, tetrasporic; Kawela Bay, *Abbott 732b* on *Padina*, sterile. **Maui Island:** *E. Bailey 7*, 5 specimens of which two are tetrasporic, others sterile.

The persistent dichotomous branching of the Hawaiian specimens is a very misleading character since *Griffithsia tenuis* of other writers is taxonomically characterized by having lateral, secund branches. One collection of fifteen sets shows the secund habit of the species. These plants were epiphytic on a small *Sargassum echinocarpum*, and on *Champia* sp. The Hawaiian specimens appear to be more narrow in the size of the cells and have smaller tetraspores than the Atlantic and China specimens. The specimens collected at Hanauma Bay, in addition, show only four tetraspores in a whorl at the nodes and the pedicels are not typically clavate or pyriform as in the Waikiki specimens. These differences, however, may perhaps be attributed to the tide pool habitat of the former.

The appearance of tetraspores and cystocarps on the same plant is not rare for the Ceramiales (see Kylin, 1928, Drew, 1944), but is newly reported for *G. tenuis*. Unfortunately, I have not studied the species cytologically.

4. Griffithsia Binderiana Sonder, Bot. Zeit. **3**:52, 1845.

Bornetia Binderiana (Sond.) Zanard., Iconogr. Phycol. Med.-Adr. **2**:45. 1865 (cited by Børgeson, F. Danske Vidensk. Selsk., Biol. Medd. **19**(10):16. 1945).
(See other references for this species by Sonder in literature cited.)

PLATE IV, FIGS. 1–7

Plants tufted, to 4 cm. in height, much branched, subdistichous, dichotomous, furcate at the tips. Cells are subcylindrical, 300–500 μ in width, 2.5 to 3 times as long in the central parts of the filaments, cells becoming gradually smaller toward the terminal ends. Tetraspores are

borne on characteristic cuneate or ovoid, solitary, secund pedicels; the tetraspores are surrounded by a prominent incurved involucre. Tetraspores are 50–60 μ in diameter. Three or more tetrasporangia are clustered on a common stalk. Rhizoids occur chiefly in the basal parts, but in some ecological forms they may occasionally appear laterally throughout the plant.

Type locality: "ad litus occidentale Novae Holland."

Hawaiian specimens examined: **Oahu Island:** near Elk's club, Waikiki, *Abbott 467*, sterile; Laie Bay at Makahoa Point, *Abbott 468*, tetrasporic; *Abbott 659*, spermatangial; *Abbott 660*, cystocarpic; *Abbott 661*, tetrasporic; *J. T. Conover* at Barber's Point, tetrasporic; *R. S. Cowan* at Nimitz Recreation Beach, south Ewa, near Barber's Point, tetrasporic; *J. F. Rock* from Honolulu Harbor, sterile. **Maui Island:** Paia, *E. Bailey* without number, some tetrasporic, others sterile.

The prominent lateral branches bearing involucrate tetraspores are most characteristic of this species, and fortunately the cystocarpic and spermatangial plants also show this characteristic well. The development of the cystocarp follows that of *G. corallina*, *G. Metcalfii* and *G. tenuis*. Spermatangial and cystocarpic plants have been found in the winter months, the tetrasporic plants throughout the year. Spermatangial and cystocarpic plants are reported for the first time.

Griffithsia Binderiana seems to be related to the oriental *G. subcylindrica* Okamura, especially in the vegetative structure. The cells of the latter appear to be larger both in width and length. The Hawaiian plants compare favorably with Harvey's description of specimens of *G. Binderiana* from Rottnest.

5. Griffithsia rhizophora Grunow *ex* Weber-van Bosse, Siboga Expeditie. Monograph **59c**:313. 1923.

PLATE I, FIGS. 5–9

Frond to 2 cm. in height, caespitose. Branches are convergent at the tips, otherwise subdichotomous and erect, or creeping. The cells are moniliform except at the base where they are subcylindrical. The central cells of the filaments are 400–500 μ in diameter with the same length. Terminal cells are somewhat less than 100 μ, basal cells 500 μ in diameter and twice as long. Tetraspores without involucre.

Type specimen: Ferguson 316, in Algae of Ceylon.

Distribution: Ceylon, Hainan, Malaya.

Hawaiian specimens examined: **Oahu Island:** Laie Bay, *Abbott 466*, tetrasporic; Waimanalo, 3 miles north of Makapuu Point, *Abbott 909a* on *Dictyota*, sterile; *Abbott 910a* on *Padina*, sterile; Wailupe, east of fishpond, *Abbott 802a* on *Dictyota*, sterile; Diamond Head, below lighthouse, *Abbott 816a* on *Sargassum*, sterile; Kaalawai, *Abbott 663a* on *Padina*, sterile; Kawela Bay, *Abbott 715a* on *Halimeda*, sterile.

The regular subdichotomous branching and the convergent tips of this species separate it vegetatively from *Griffithsia Metcalfii*. The latter plant is also larger. Of the Hawaiian species of *Griffithsia* studied, this

one is least known since only one fertile specimen was collected. The identification, therefore, should be considered to be tentative.

Griffithsia rhizophora was named by Grunow on a herbarium sheet (*nomen nudum*). Later, Madame Weber-van Bosse published it in the list of Siboga Algae, crediting it to Grunow. Article 48, section 7 of the International Rules states the ". . . name of the latter author must be appended to the citation with the connecting word *ex*." The listing of the species should be as above.

The writer wishes to thank Dr. George F. Papenfuss of the University of California who has helped greatly in checking literature she was not able to see.

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LITERATURE CITED

Agardh, C. A. Species Algarum. **2**(1): 131. 1828.

Askenasy, Eugen. Algae *in* Forschungsreise S.M.S.Gazelle . . . 1874–bis 1876. **4:** 36. pl. 9, figs. 1–4. 1889.

Børgesen, F. Marine algae of the Danish West Indies II. Dansk Bot. Arkiv. **3:** 462–464. 1915–20.

Drew, K. M. Nuclear and somatic phases in the Florideae. Biol. Rev. Camb. Phil. Soc. **19:** 113–117. 1944.

Harvey, W. H. Phycologia Australica **4:** 203. 1862.

Kylin, H. Die Entwicklungsgeschichte von Griffithsia corallina (Lightf.) Ag. Zeit. f. Bot. **8:** 99. 1916.

———. Entwicklungsgeschichtliche Florideenstudien. Lunds Univ. Arsskrift, N. F., **2:** 24. 1928.

MacCaughey, Vaughan. The algae of the Hawaiian Archipelago. (Thrum's) Hawaiian Almanac and Annual for **1918:** 154. 1917.

Neal, Marie C. Hawaiian marine algae. Bishop Museum Bull. **67:** 73–74. 1930.

Reed, Minnie. The economic seaweeds of Hawaii and their food value. Hawaii Agr. Exp. Sta. Ann. Rept. for **1906:** 87. 1907.

Reinbold, Th. Meeresalgen *in* Rechinger, K. Bot. und Zool. Ergebnisse einer wissenschaftlichen Forschungsreise nach den Samoainseln, dem Neuguinea-Archipel und den Salomonsinseln. **1:** 10. 1907.

Setchell, W. A. American Samoa: Pt. 1. Vegetation of Tutuila Island. Carnegie Inst. Wash. **20:** 159–160. 1924.

Sonder, O. G. Nova Algarum genera et species quas in itinere ad oras occidentalis Novae Hollandiae collegit L. Preiss, Ph. Dr. Bot. Zeit. **3:** 52. 1845.

———. *in* Lehmann, Johann Georg C. Plantae Preissianae, sive enumeratio Plantarum quas in Australasia occidentali et meridionali-occidentali annis 1838–41 collegit L. Preiss. **2:** 168. 1846–47.

———. *in* Plantae Preissianae (reprint with different pagination, referred to by J. Agardh) p. 21.

Tseng, C. K. Studies on Chinese species of Griffithsia. Papers Mich. Acad. Sci., Arts, and Letters, **27:** 111–116. 1942.

Weber-van Bosse, Anna. Liste des algues du Siboga. Siboga Expeditie. Monographie **59c** (3): 313–314. 1923.

PLATE I

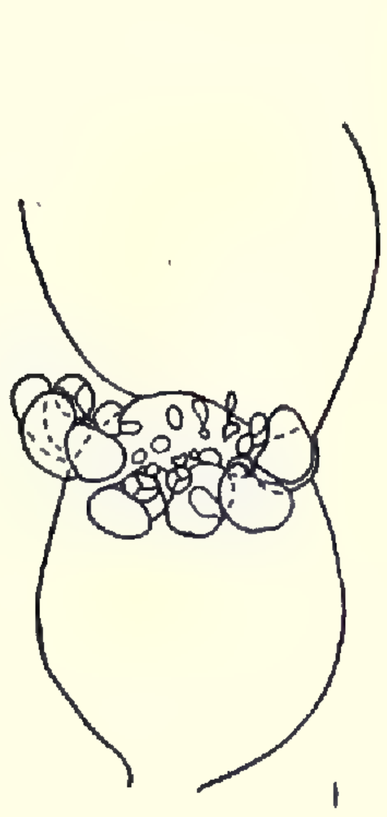
All figures are drawn with the aid of a camera lucida. Each unit of scale A equals 200 μ; scale B, 100 μ; scale C, 50 μ; scale D, 10 μ.

Griffithsia ovalis Harvey. Figs. 1–4.

1. Vegetative cells with involucrate tetrasporangia between the articulations. (Scale B)
2. Habit of repent specimen showing rhizoid. (Scale A)
3. Involucrate tetrasporangia near tip of plant. (Scale B)
4. Mature tetrasporangium on a pedicel. (Scale D)

Griffithsia rhizophora Grunow *ex* Weber-van Bosse. Figs. 5–9.

5. (Upper figure) Mature tetrasporangia. (Scale D); (lower figure) tetrasporangia on pedicel. (Scale C)
6. Habit of typical specimen with forcipate tips. (Scale B)
7. Habit of repent specimen with rhizoids. (Scale C)
8. Tetrasporic plant. (Scale C)
9. Habit of specimen with nearly straight tips. (Scale B)



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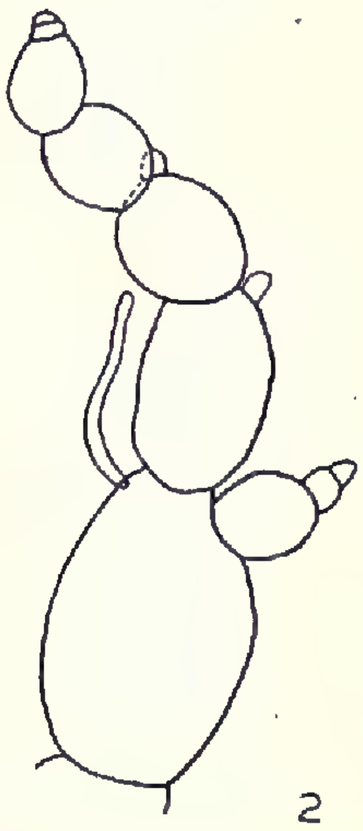

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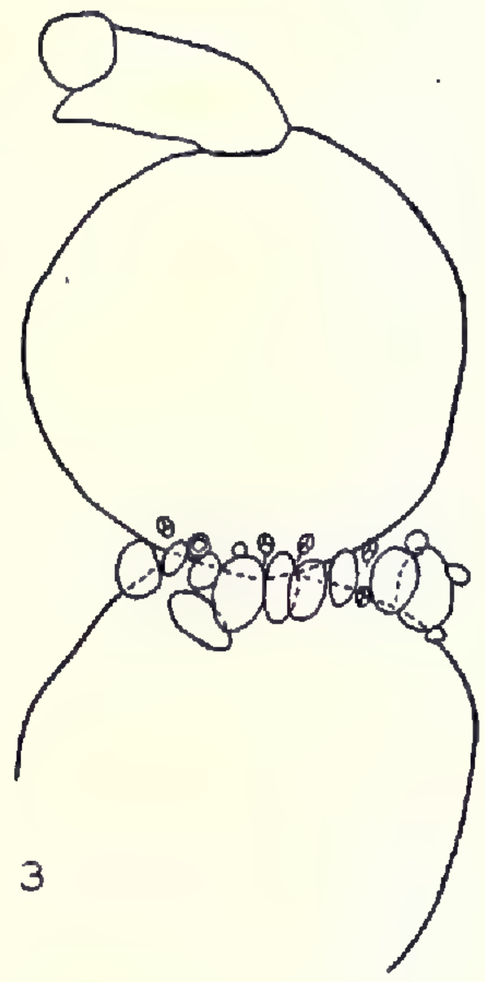

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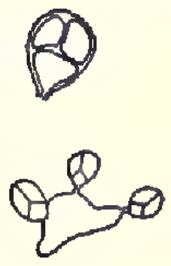

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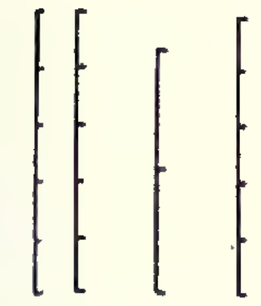

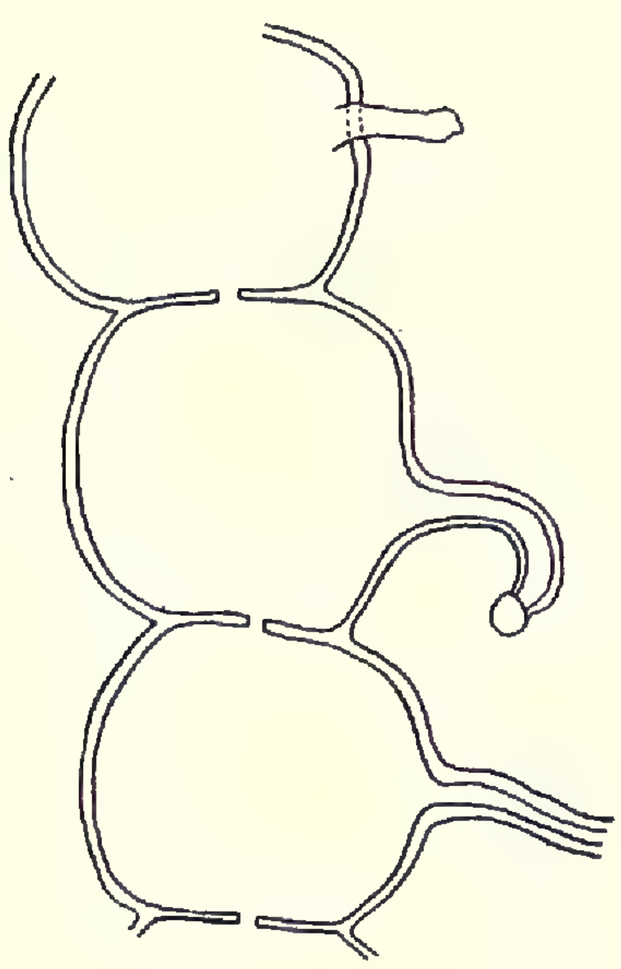

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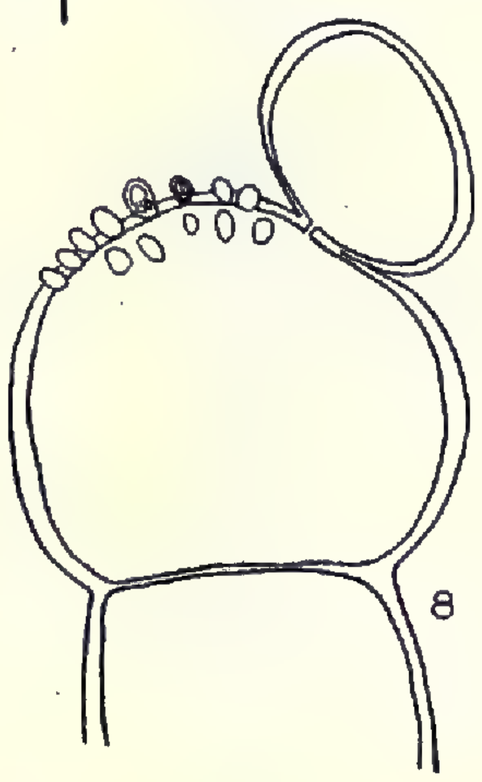

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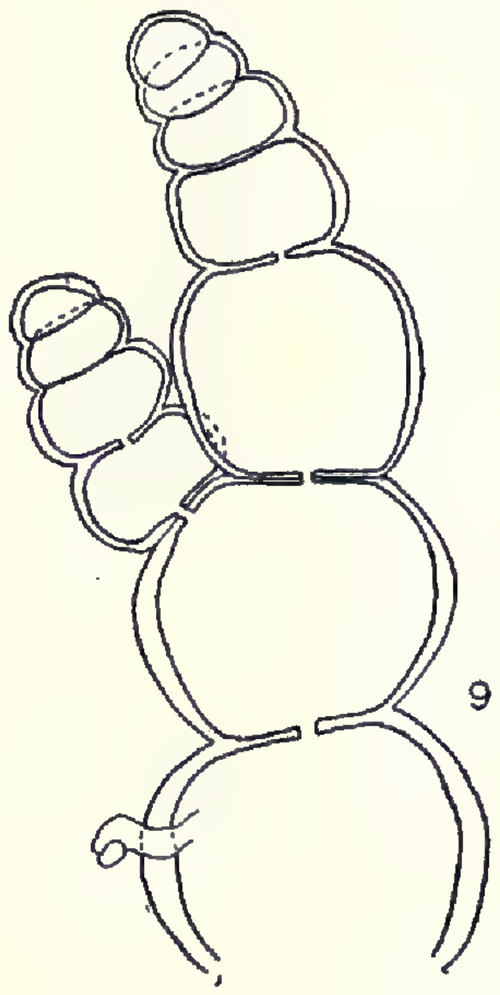

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PLATE I

PLATE II

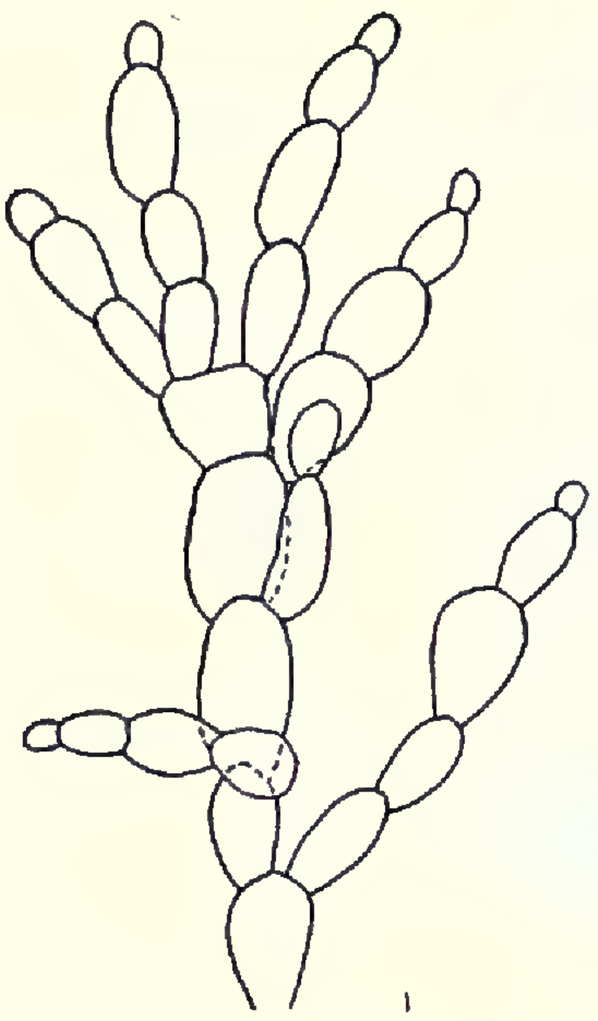
All figures are drawn with the aid of a camera lucida. Each unit of scale A equals 200 μ; scale B, 100 μ; scale D, 10 μ.

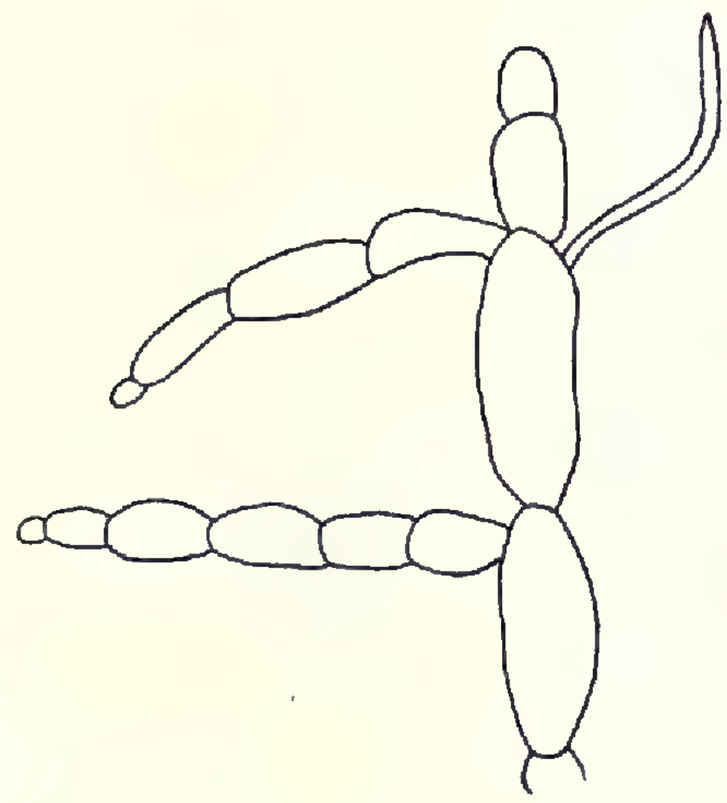
Griffithsia ovalis Harvey. Figs. 1–2.

1. Habit of erect specimen showing fastigiate branching. (Scale A)
2. Habit of creeping specimen showing secund branching. (Scale A)

Griffithsia Metcalfii Tseng. Figs. 3–6.

3. Tetraspores between articulations of vegetative cells. (Scale B)
4. Tip of a frond. (Scale B)
5. Spermatangial cluster. (Scale D)
6. Tetrasporic cluster. (Scale D)





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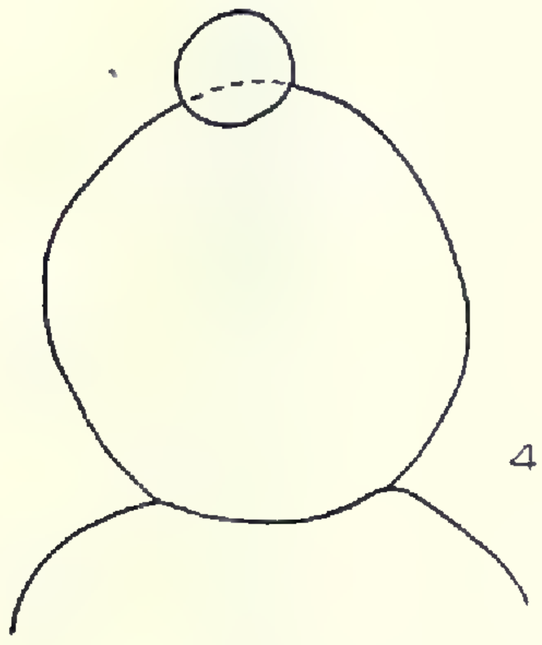

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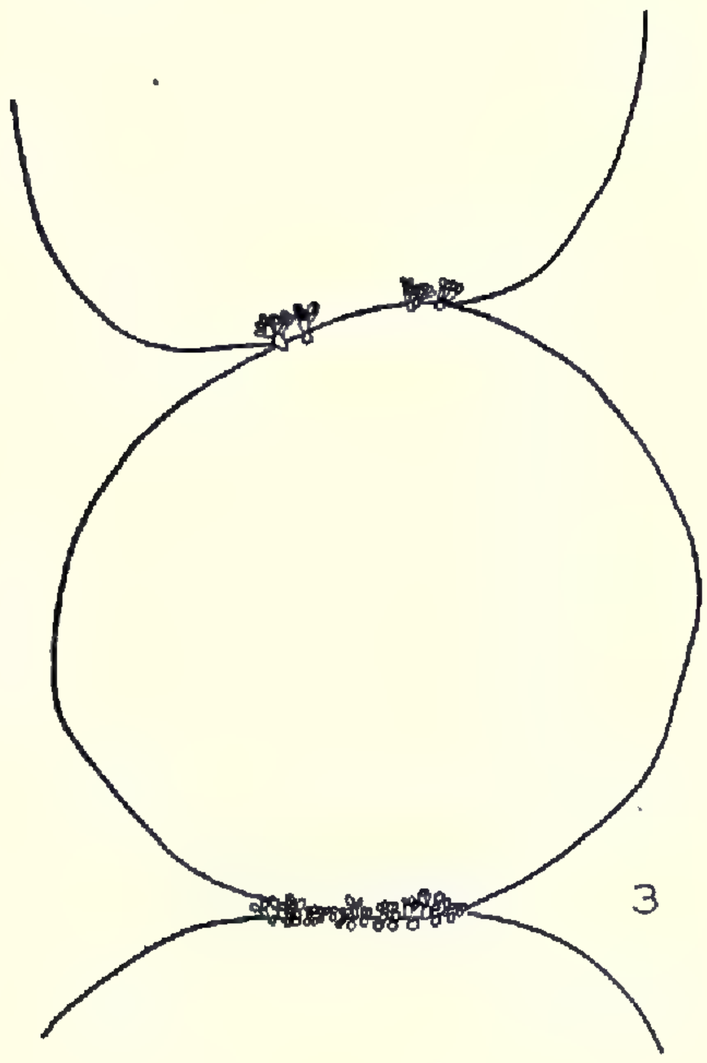
A B D



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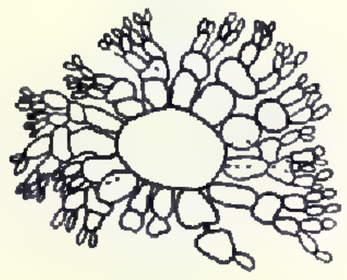

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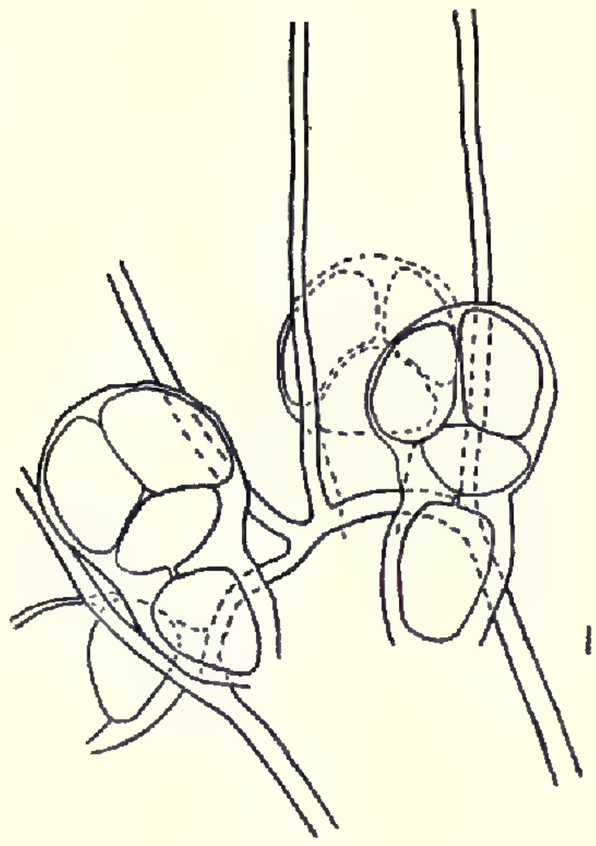
PLATE II

PLATE III

All figures are drawn with the aid of a camera lucida. Each unit of scale B equals 100 μ; scale C, 50 μ; scale D, 10 μ.

Griffithsia tenuis C. Agardh. Figs. 1–7.

1. Whorl of four tetrasporangia. (Scale C)
2. Habit of specimen with male cluster. (Scale B)
3. Spermatangial cluster. (Scale D)
4. Habit of robust specimen, showing young tetraspore. (Scale C)
5. Part of cystocarp, showing supporting cell derivatives and pyriform carpospores. (Scale D)
6. Involucrate cystocarp on lateral pedicel. (Scale C)
7. Young gonimoblast with involucre. (Scale D)



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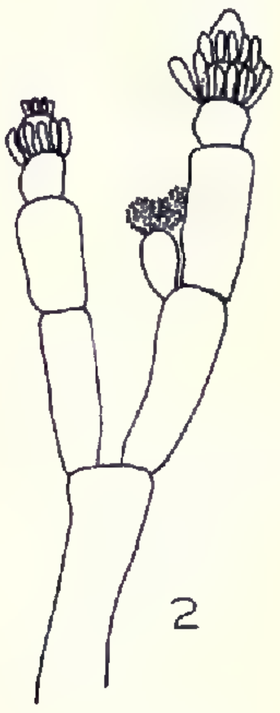

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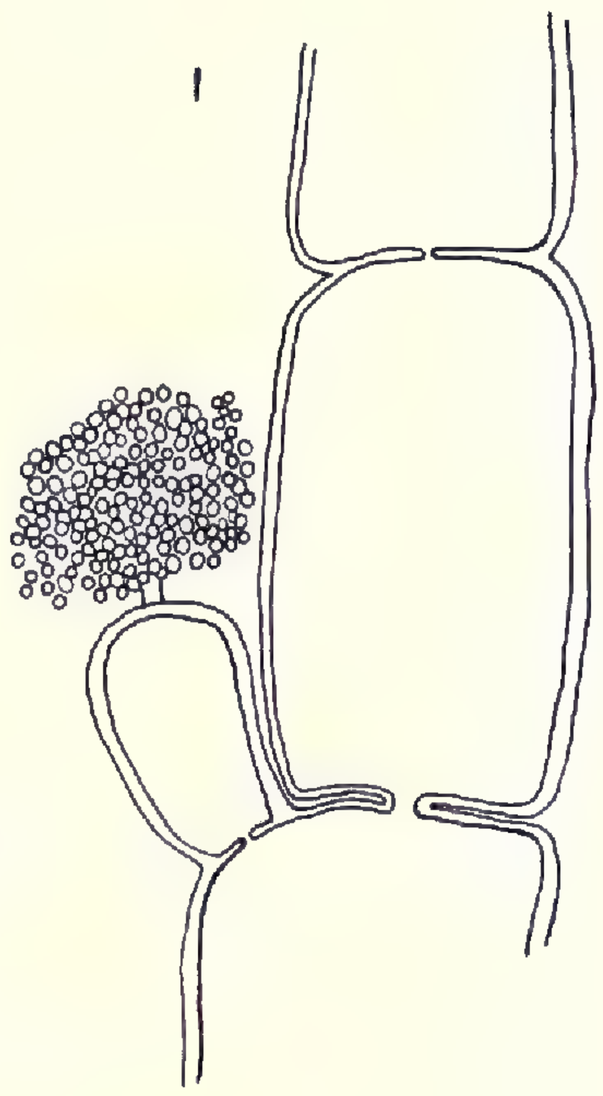

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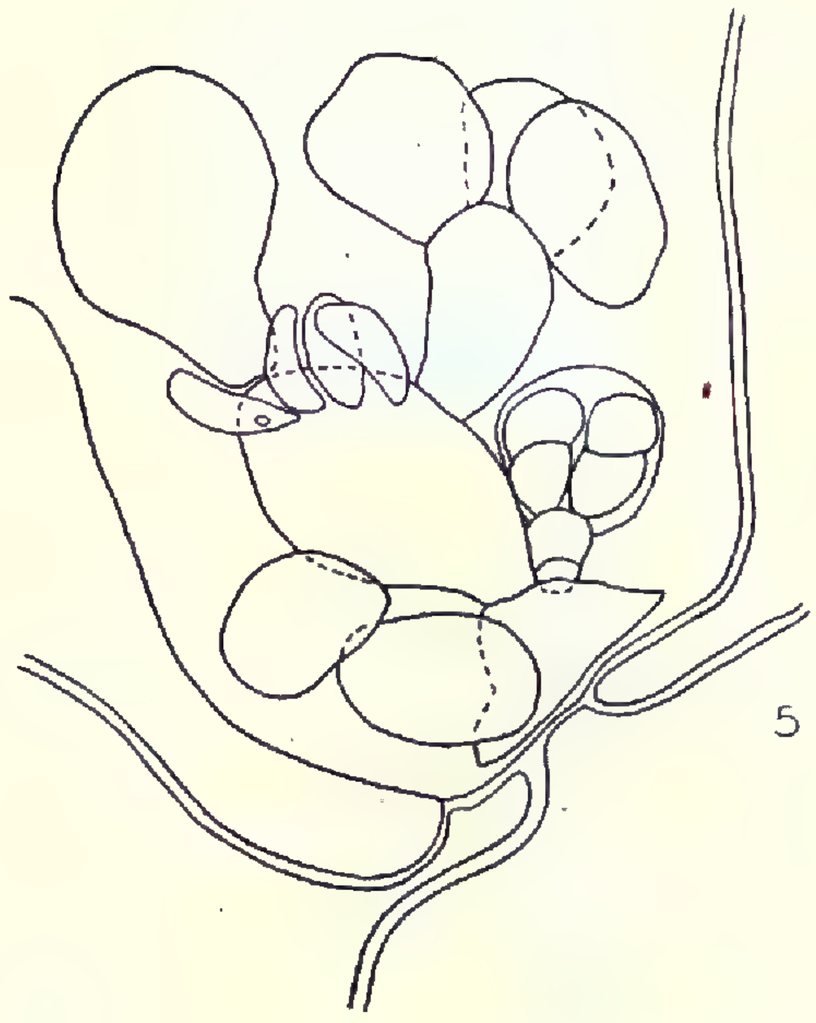

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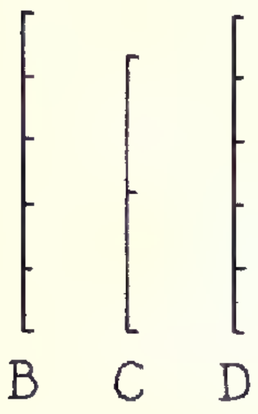

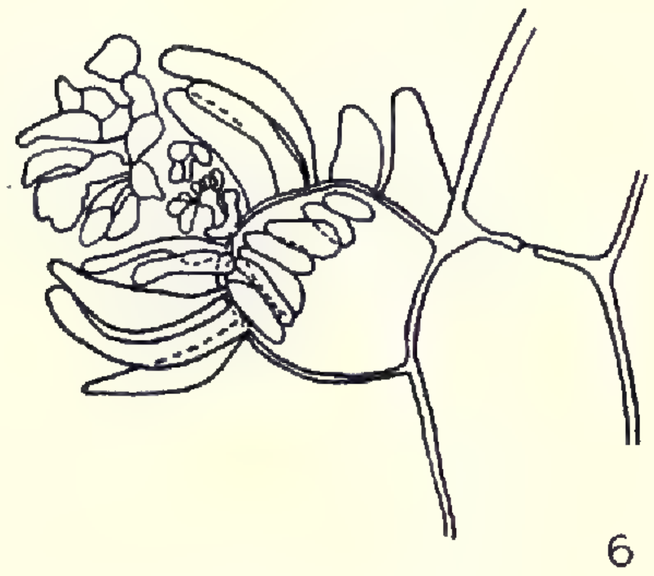

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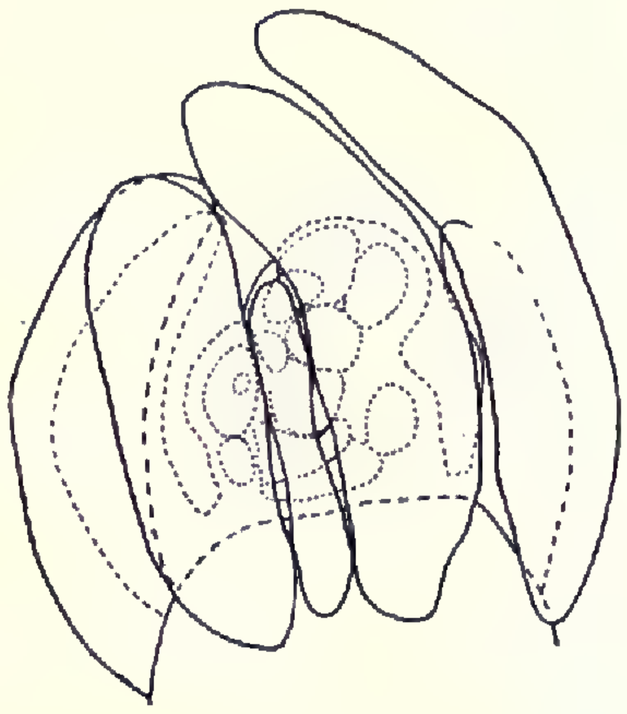

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PLATE III

PLATE IV

All figures are drawn with the aid of a camera lucida. Each unit of scale B equals 100 μ; scale C, 50 μ; scale D, 10 μ.

Griffithsia Binderiana Sonder. Figs. 1–7.

1. Habit of portion of tetrasporic plant. (Scale B)
2. Spermatangial cluster with young involucre. (Scale D)
3. Spermatangial cluster on lateral pedicel, with surrounding involucral cells. (Scale B)
4. Detail of mature cystocarp showing a few carpospores. (Scale C)
5. Tetrasporic plant with involucrate tetrasporangia. (Scale B)
6. (a) Young tetraspore; (b) mature tetrasporangium showing pedicel. (Scale D)
7. Position of cystocarp with regard to involucre on a lateral pedicel. (Scale B)

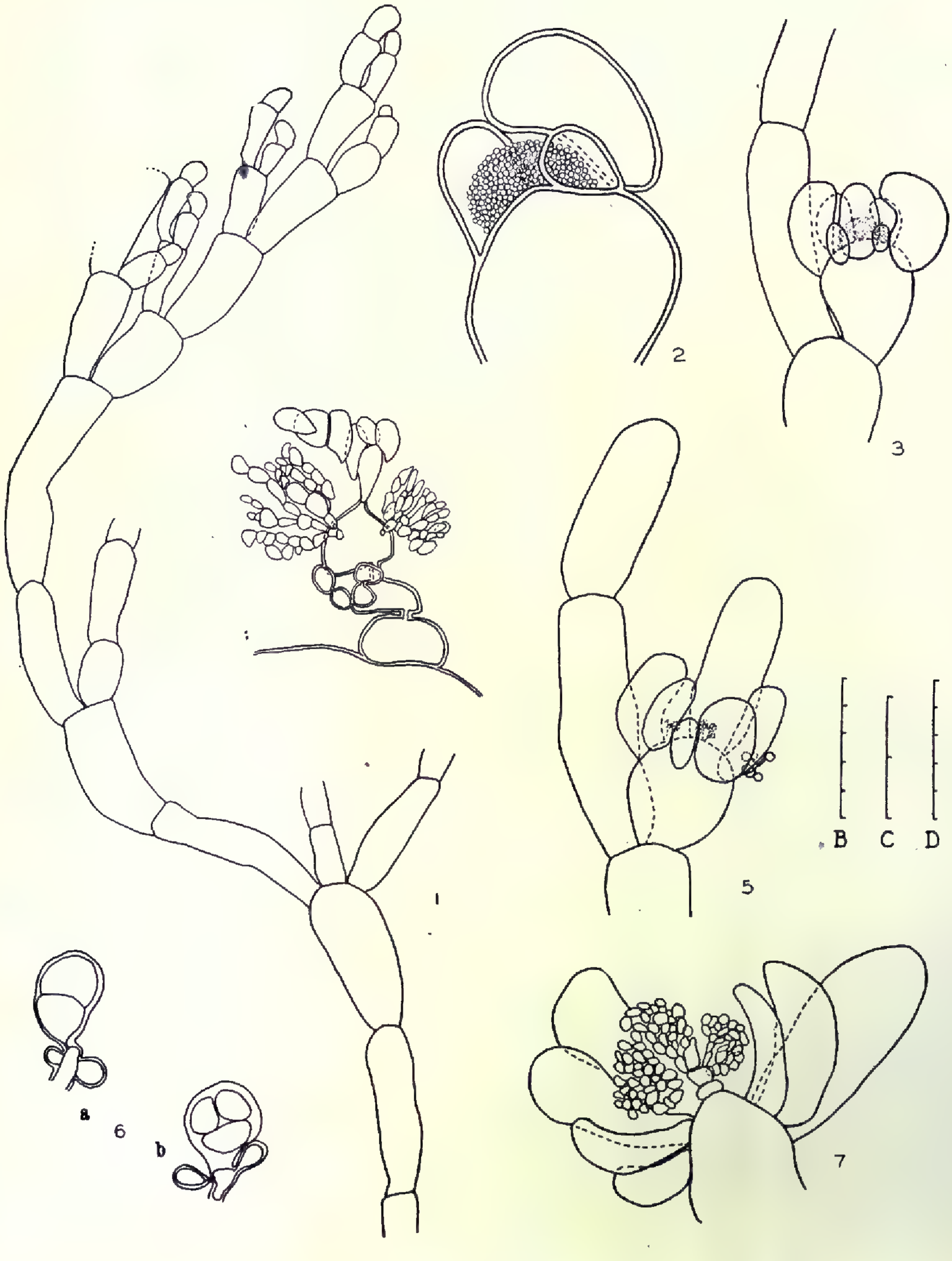

PLATE IV

2(4):455–473 FARLOWIA JULY, 1946

FUNGI DOMINGENSES NOVI VEL MINUS COGNITI. I.

CARLOS E. CHARDON

From May to November 1937, the writer was engaged by His Excellency President Rafael L. Trujillo as head of a party in charge of a partial survey of the natural resources of the Dominican Republic. Ample travel facilities, which permitted him to cover most of the territory of that country, were generously placed at his disposal.

A particularly interesting trip which lasted seven days was made on horseback from Jarabacoa to San José de Ocoa, in the company of Prof. H. A. Meyerhoff. The trail, which reaches an altitude of 2,400 meters, leads across the Cordillera Central through large and little-explored pine forests. A delightful temperate climate prevailed in these mountains and several days were spent botanizing in this *terra incognita* to mycology. Frequent collections were also made as time permitted, in other sections of the country. In short, close to a thousand specimens of fungi were collected which were sent to Prof. H. H. Whetzel to be added to the collections from the Dominican Republic previously made by M. F. Barrus, F. D. Kern, R. A. Toro, and the writer, and deposited in the herbarium of the Department of Plant Pathology, Cornell University.

The present contribution to the fungous flora of the Dominican Republic represents an addition of forty-four species, of which fourteen are apparently new to science. The writer wishes to acknowledge his thanks to the late Prof. H. H. Whetzel, of Cornell University, for encouragement and helpful suggestions; to Dr. Fred J. Seaver, of the New York Botanical Garden, for the determination of the Discomycetes and Hypocreales; and to Miss Edith K. Cash, of the U. S. Department of Agriculture, for contributing the description of a new species of the Phacidiales.

PEZIZALES

In Ciferri's "Micoflora Domingensis" (2) there are reported only three species of Discomycetes proper, all of which are common and well-known tropical forms. Ciferri's record is based on the paper published by Berkeley in 1852, "Enumeration of some fungi from Santo Domingo" (1), which was the first contribution published on the fungous flora of the Dominican Republic. The species are: *Cookeina sulcipes* (Berk.) Kuntze, *Cookeina tricholoma* (Mont.) Kuntze, and *Phillipsia domingensis* (Berk.) Berk.

Since the appearance of Berkeley's paper, ninety-two years ago, and in spite of the intensive collections made in the last twenty years by half a dozen explorers, not a single cup-fungus has been added to Berkeley's original list. This group of fungi has been overlooked because of its sapro-

phytic nature, the former mycologists having been interested in parasitic forms only.

We have made an effort to collect cup-fungi and have contributed thirteen specimens, representing nine different species, of which seven are new to the flora, and one is new to science. All the Discomycetes included below were determined by Dr. Fred J. Seaver, of the New York Botanical Garden.

This brings the total of known Pezizales in the Dominican Republic to ten species. In Puerto Rico, the number of species of this group reported by Seaver and Chardon (4) is forty-seven. Our list, consequently, is a mere beginning and could be multiplied many-fold by subsequent explorations.

The most common species found was the cosmopolitan *Cookeina sulcipes* forming beautiful conspicuous cups on dead sticks and debris in the shade. Cacao plantations furnish ideal conditions for its growth and the cups are found by the hundreds. *Cookeina tricholoma* and *Phillipsia domingensis* require the same habitat but are far less common.

The attractive *Ascobolus magnificus*, common in Puerto Rico, was encountered twice, always on dung, in the shade. *Erinella calospora* and *E. longispora* were both found on the bark of trees in the tropical region.

All the other species were found at much higher altitudes. On our trip to Constanza Valley, at the high point in Loma Barrero, along the trail just above Jarabacoa, we found two specimens on dung in a forest: *Ascophanus granulatus* and *Patella theleboides*. The altitude was 1150 meters. Further along, a third species was found, *Saccobolus Kerverni*. All these species are almost exclusively temperate species.

At Valle Nuevo, at an altitude of 2250 meters, where intense cold was felt all the time, we found *Patella coprinaria* on dung in the meadows near an old abandoned hut. This is the highest station at which a Discomycete has been found in the West Indies. This is also a temperate-zone species. It is not known in the tropical and subtropical zones, except for a single collection in the Luquillo Mountains of Puerto Rico.

Ascobolus magnificus Dodge, Mycologia **4:** 218. 1912.

First described from Puerto Rico, where it is common on cow dung. Also known from the Cauca Valley (Colombia) and New York City, where it has been cultivated in damp-chambers. Careful search for this species was rewarded by the collection of two specimens. The cup-shaped apothecia with the dark violet hymenium at maturity are typical.

On cow dung, Prov. Samana, in forests at Sabana la Mar, *Chardon 703*, July 5, 1937; Prov. La Vega, in shaded places near Jarabacoa, *Chardon 1136*, Sept. 13, 1937.

Ascophanus granulatus (Bull.) Speg., Michelia **1:** 235. 1879.

Small apothecia, 1–2 mm. in diameter, pale orange, with the concave hymenium orange. A common temperate-zone species.

On cow dung, Prov. La Vega, trail from Jarabacoa to Constanza, 1100–1200 m., *Chardon 1139*, Sept. 13, 1937.

Cookeina sulcipes (Berk.) Kuntze, Rev. Gen. Pl. **2:** 849. 1891.

One of the commonest and most conspicuous cup-fungi in the American tropics; also known from Australia. The cups are deep orange to rose color, attaining a diameter of 2 cms. or more. Specimens nos. *722* and *735* were collected among many hundreds of cups found in a well-sheltered cacao plantation, where moisture and shade afforded ideal conditions for development. Again at El Hatillo (specimen no. *1117*) the cups were very abundant, literally covering portions of the floor of a dense, humid forest.

On dead wood and forest debris, Prov. Samanas, Cacao plantations near Sabana la Mar, *Chardon 722* & *735*, July 5, 1937; Cacao plantations above Samana, Peninsula de Samana, *Chardon 739*, July 6, 1937; Prov. La Vega, forests at El Hatillo, *Chardon 1117*, Aug. 28, 1937.

Cookeina tricholoma (Mont.) Kuntze, Rev. Gen. Pl. **2:** 849. 1891.

Also known throughout the American tropics and Old World tropics. Of less frequent occurrence than the preceding species, the specimen cited below consisting of three apothecia. Cups red or deep red, externally clothed with long hairs.

On dead wood, Prov. La Vega, forests at El Hatillo, *Chardon 1231*, Aug. 28, 1937.

Erinella calospora Pat. & Gaill., Bull. Soc. Myc. Fr. **4:** 101, 1889.

On living bark of *Jambos*, Prov. La Vega, forests at El Hatillo, *Chardon 1231*, Aug. 28, 1937.

Erinella longispora (Karst.) Sacc., Syll. Fung. **8:** 507. 1889.

On dead wood, Prov. La Vega, forests, road to Cotui, *Chardon 975*, Aug. 6, 1937.

Saccobolus Kerverni (Crouan) Boudier, Ann. Sci. Nat. Ser. V. **10:** 229. 1869.

This species, with the exception of a single collection from Puerto Rico, occurs in the temperate regions of the world. It is common throughout North America and Europe, and is also found in Bermuda.

On cow dung, Prov. La Vega, trail from Jarabacoa to Constanza, 1100–1200 m., *Chardon 1140*, Sept. 13, 1937.

Patella coprinaria (Cooke) Seaver, N. Amer. Cup-Fungi 171. 1928.

Apothecia small, 2–3 mm. in diameter, bright yellow in color, bordered with hairs. This is a temperate-zone species, occurring in the United States and Europe. Its appearance in the temperate zone of Hispaniola may be significant in elucidating problems of geographical distribution.

On cow dung in meadows, Prov. La Vega, Valle Nuevo, above Constanza, Cordillera Central, 2250 m., *Chardon 1227*, Sept. 16, 1937

Patella theleboides (Alb. & Schw.) Seaver, N. Amer. Cup-Fungi, 170. 1928.

Apothecia densely crowded, small, 2–3 mm. in diameter, bright yellow. Another temperate-zone species, reported in the United States, from Connecticut and Delaware to California; also in Europe.

On cow dung in the shade, Prov. La Vega, trail from Jarabacoa to Constanza, 1100–1200 m., *Chardon 1140*, Sept. 13, 1937.

PHACIDIALES

Nymanomyces Xolismae Cash sp. nov.

FIGURES 1–4

Stromata sparsa, atra, pulvinata, subcarbonacea, subcircularia, 2–3 mm. in diam., epidermicalia, amphigena; ascomata hypophylla, singularia, subcircularia, 1–2 mm. in diam., rima longitudinali vel lobis pluribus aperientia, hymenio brunneo; asci elongato-clavati, octospori, 100–150 x 18–25 μ; ascosporae elongato-ellipsoideae vel subclavatae, 1–3-seriatae, viridi-brunneae, 25–32 x 5–6 μ; paraphyses filiformes, subhyalinae; hypothecium atrum, plectenchymaticum, margine incrassato; pycnidia amphigena, loculata; pycnosporae parvae, hyalinae, ellipsoideae, 1.5–2 x 0.7 μ.

Stromata sparse, black, subcarbonaceous, round to angular, 2–3 mm. in diameter, or occasionally elongate and up to 5 mm. long, pulvinate, amphigenous, developing in the epidermis, surrounded on the lower surface by a broad, pale reddish, circular area, epiphyllous stromata sterile or pycnidial only; ascomata hypophyllous, single, subcircular, elliptical, or elongate, 1–2 mm. in diameter, opening by a longitudinal slit or more often by several lobes, the covering layer later breaking up and falling away, hymenium dark brown; asci long-clavate, gradually narrowed to a long pedicel, rounded at the apex, 8-spored, 100–120 (–150 x 18–20 (–25) μ; ascospores unicellular, narrow-ellipsoid or subclavate, sometimes slightly constricted near the center, obliquely uniseriate below, irregularly 2–3-seriate above, greenish-brown, the granulose contents occasionally containing one or two large hyaline guttules, 25–32 x 5–6 μ; paraphyses filiform, numerous, subhyaline to pale brownish, longer than the asci; hypothecial layer narrow, black, plectenchymatic, dense, and very much thickened toward the margin. Pycnidia amphigenous, when hypophyllous developing from the same stromata as the apothecia, irregularly chambered, the locules frequently becoming confluent and extending over most of the surface of the stroma; spores minute, hyaline, ellipsoid, filling the locules, 1.5–2 x 0.7–1 μ, emerging through irregular fissures and forming a white mass on the surface of the stroma; conidiophores not seen.

On *Xolisma* sp. (det. N. Y. Bot. Garden), Valle Nuevo, above Constanza, Prov. La Vega, Sept. 16, 1937, no. *1189* (**type**) and Sept. 17, 1937, *Carlos E. Chardon 1195*. Type specimen in the Mycological Collections of the Bureau of Plant Industry, Beltsville, Maryland; at Cornell University and in Chardon herbarium.

The only similar species described on an ericaceous host is *Criella leucothoes* P. Henn., which occurs in Brazil on an undetermined species of *Leucothoe*. No specimens of this species were available for comparison, but it appears to differ from the fungus on *Xolisma* in the epiphyllous stromata and much broader spores.

HYPOCREALES

Cordyceps militaris (L.) Link, Handb. **3:** 347. 1833.

On pupa of an insect, Prov. Monte Cristi, forests back of Copey, *Chardon 520*, June 8, 1937.

Hypocrea citrina (Pers.) Fries, Summa Veg. Scand. p. 185. 1849.

On dead wood, Prov. La Vega, trail from Maimón to Yuna River, *Chardon 1030*, Aug. 13, 1937.

Hypocrea patella Cooke & Peck; Peck, Ann. Rep. N. Y. State Mus. **29:** 57. 1878.

On dead wood, Prov. La Vega, road to Cotui, *Chardon 966*, Aug. 6, 1939.

Hypocrea rufa (Pers.) Fries, Summa Veg. Scand. p. 383. 1849.

On dead wood, Prov. La Vega, road to Bonao, *Chardon 797*, July 18, 1937.

Stilbocrea hypocreoides (Kalchbr. & Cooke) Seaver, Mycologia **2:** 62. 1910.

Sphaerostilbe hypocreoides Kalchbr. & Cooke, Grevillea **9:** 26. 1880.
Sphaerostilbe intermedia Ferd. & Winge, Bot. Tidssk. **29:** 12. 1908.

On dead wood, Prov. Monte Cristi, forests back of Copey, *Chardon 520*, June 8, 1937.

DOTHIDEALES

Dothidella domingensis Chardon sp. nov.

FIGURES 9–13

Stromata semper amphigena, atra, crustosa, conspicua, supra superficiem folii elevata, fere rotundata, 1 mm. diam., partem magnam folii tegentia, dothideacea (e cellulis distinctis fuscis composita); loculi 2–7 in quoque stromate, globosi, 96–120 μ diam.; asci clavato-cylindracei, octospori, 107–124 x 15–18 μ; sporae apice et basi monostichae, medio distichae, uniseptatae, hyalinae, longe ellipsoideae, una cellula majore obtusa, altera minore subacuta, 24–27 x 7–8 μ, leves, sine tunica crassa; paraphyses carentes.

Stromata amphigenous only, black, crust-like, conspicuous, raised above the surface of the leaves of the host, approximately circular, 1 mm. in diameter, covering a large portion of the leaf, dothideaceous (made up of distinct, dark-brown cells); locules several, 2–7 in each stroma, globose, 96–120 μ in diameter; asci cylindrical-clavate, 8-spored, 107–124 x 15–18 μ, with the spores uniseriate at the top and bottom, biseriate in the main body of the ascus; spores 1-septate, hyaline, long-elliptical, with one cell larger and with an obtuse end, the other cell smaller with a subacute end, 24–27 x 7–8 μ, surface smooth, without a thick cell wall; paraphyses absent.

The fungus looks superficially like *Dothidella tinctoria* (Tul.) Sacc., common on Compositae in the upper subtropical and temperate zone of the Andes of Venezuela and Colombia. In fact it looked identical to us, until a microscopic study disclosed that it was a new species. The spores were in asci (which is rarely observed in *D. tinctoria* where the spores are loose from a very early stage). The ascospores are also different; they are hyaline, 1-septate, with two unequal cells, and no thick cell wall was found. In *D. tinctoria* the cells are equal, the spores larger, 26–30 x 5–6 μ, the contents granular, and a thick cell wall envelops the ascospore.

For the marked differences cited above, reference is made to Figures 12 and 13.

On *Baccharis myrsinites* (Lam.) Pers., along trail from Jarabacoa to Constanza, Cordillera Central, 1300 m., *Chardon 1142*, Sept. 13, 1937 (**type**).

Trabutia conica Chardon, Mycologia **13:** 292. 1921.

The type is *Whetzel & Olive 658*, from Mayaguez, Puerto Rico, on *Drepanocarpus lunatus*, with which our material compares well. The species is known to occur also in Venezuela (*Chardon & Toro 474*), on *Lonchocarpus punctatus*. Not known elsewhere. The stromata are typically conical, epiphyllous, circular, about 1 mm. across, black, shiny, uniloculate, located between the cuticle and the epidermis. Spores globose, 9–11 μ, inordinately placed in the ascus.

On *Drepanocarpus lunatus* (L.f.) G. Meyer, Prov. Puerto Plata, road to Blanco, *Ciferri 4871*, June 15, 1931 (in Chardon's herb.).

Trabutia Danthoniae Chardon sp. nov.

Stromata atra, graminicola, linearia, 1 mm. longa, 0.5 mm. lata, interdum confluentia longioria et leviter elevata, subcuticularia; loculi 1–2 in quoque stromate, applanato-lenticulares, 150–240 x 74–90 μ, primo stylosporas longas, filiformes, 25–28 x 1 μ, posterius ascos gignens; asci clavati, octospori, 70–85 x 17–21 μ; sporae distichae, hyalinae usque subhyalinae, continuae, longe ellipsoideae, apice subacuto, 19–25 x 7–9 μ; paraphyses praesentes.

Stromata small, black, graminicolous, linear, 1 mm. long, 0.5 mm. wide, sometimes confluent and forming longer stromata slightly raised, subcuticular; locules 1–2 in a stroma, flat-lenticular, 150–240 x 74–90 μ, giving rise first to long, cylindrical stylospores, 25–28 x 1 μ, later to asci; asci clavate, 8-spored, 70–85 x 17–21 μ, with the spores biseriate; spores hyaline to subhyaline, 1-celled, long ellipsoidal with one end subacute, 19–25 x 7–9 μ; paraphyses present.

This interesting species forms inconspicuous stromata on a grass which is peculiar to and widespread in the higher elevations of the Cordillera Central. The subcuticular character of the stroma makes the fungus fall under *Trabutia*.

On *Danthonia domingensis* Hack. and Pilger, Prov. Azua, trail from Valle Nuevo to Rio de las Cuevas, Cordillera Central, 1770 m., *Chardon 1200*, Sept. 17, 1937 (**type**).

Phaeotrabutia Smilacis Chardon sp. nov.

Stromata epiphylla, rotundata, nigra, lucida, conspicua, 1–3 mm. diam., inter cuticulam et epidermidem folii definite insidentia; loculi generaliter singuli, applanati, 650–720 x 85–95 μ, supra clypeo denso atro, infra membrana tenui stromatica, brunnea praediti, interdum loculi 2–3, 320–410 x 80–90 μ; asci clavati usque cylindro-clavati, octospori, 123–135 x 29–38.5 μ; sporae in parte praecipua asci distichae, continuae, clare brunneae, ellipticae, 19–25 x 8.5–11 μ; paraphyses filiformes.

Stromata epiphyllous, circular, black, shiny, conspicuous, 1–3 mm. in diam., distinctly located between the cuticle and the epidermis of the leaf; locule single, flattened, 650–720 x 85–95 μ, with a heavy black clypeus above and a thin, brown, stromatic tissue below, sometimes divided into 2 or 3 locules, 320–410 x 80–90 μ; asci clavate to cylindric-clavate, 8-spored, 123–135 x 29–38.5 μ, with the spores biseriate in the main body of the ascus; spores 1-celled, distinctly brown, elliptical, 19–25 x 8.5–11 μ; paraphyses present, filiform.

The genus *Phaeotrabutia* was recently erected by Dr. Carlos Garcés Orejuela (Caldasia No. **2:** 77. 1941) to take care of species like *Trabutia*, possessing brown spores. In our Dominican material, the stromata lie between the cuticle and the epidermis, and the spores are unicellular, distinctly brown in color.

On *Smilax coriacea* Spreng., Prov. Azua, trail from Valle Nuevo to Río de las Cuevas, Cordillera Central, 1600 m., *Chardon 1202*, Sept. 17, 1937 (**type**).

Catacauma Sabal Chardon sp. nov.

FIGURES 14–17

Stromata amphigena, in utraque superficie folii pariter visibilia, angulata, leniter elevata, sordide brunnea, conspicua, 2–3 mm. longa (axe principali axem folii sequenti), 1.5 mm. lata, subter epidermidem in maturitate distincte visibilem evoluta, mesophyllum penentrantia; loculi plures, magni, 250–420 x 93–120 μ, applanati usque labyrinthiformes, supra clypeo atro denso praediti, infra et lateraliter sine membrana stromatica; asci clavati, octospori, exigue pedicellati, 68–85 x 35–43 μ; sporae in ascis irregulariter conglobatae, continuae, hyalinae, naviculares, 28–30 x 10–12 μ, subgranulosae; paraphyses filiformes, rarae.

Stromata amphigenous, equally visible on both surfaces of the leaves of the host, angular, slightly raised, dirty brown in color, conspicuous, 2–3 mm. long (with the main axis following that of the leaf), 1.5 mm. in width, originating beneath the epidermis, and in mature stromata the epidermal layer clearly seen above, not penetrating the mesophyll; locules several, large, 250–240 x 93–120 μ, flattened to labyrinthiform, with heavy black clypeus above and no stromatic tissue below or on the sides; asci clavate, 8-spored, short-pedicellate, 68–85 x 35–43 μ, with the spores irregularly pressed in the ascus; spores 1-celled, hyaline, navicular, 28–30 x 10–12 μ, with the contents slightly granular; paraphyses filiform, scarce.

The stromata are very characteristic; they are angular, dirty brown in color. The stromata are subepidermal and the row of epidermal cells is seen clearly above the clypeus. The spores are large, navicular. The species, which is apparently new, is referred to *Catacauma* on account of the position of the stromata in the leaf tissue.

On dead leaves of *Sabal* palm, Prov. Barahona, near sulphur springs beyond Duvergé, *Chardon 760*, July 11, 1937 (**type**).

Phyllachora Acaciae P. Henn., Hedwigia **33:** 233. 1894.

Widely distributed in tropical America on various leguminous trees and shrubs; stromata very minute, punctiform, less than 0.5 mm. in diameter, visible from both surfaces of the leaf, uniloculate; asci 60–70 x 20 μ (in our specimen); spores biseriate or inordinate, long-elliptical, 14–16 x 6–7 μ.

On *Acacia* sp., Prov. Duarte, road to San Francisco de Macoris, *Chardon & Toro 851*, July 11, 1937.

Phyllachora Bourreriae Stevens & Dalbey, Bot. Gaz. **68:** 54. 1919.

Our specimen has been compared with type material, which is *Stevens 4149*, from Vega Baja, Puerto Rico. Stromata amphigenous, black, circu-

lar, 1.0–1.5 mm. in diameter, enclosing many locules; spores obliquely uniseriate, elliptical, 8.5–12.5 x 7 μ.

On *Bourreria* sp., Prov. Puerto Plata, La Cumbre, Cordillera Septentrional, *Chardon 1129*, Aug. 30, 1937.

Phyllachora Exostemae Chardon sp. nov.

Stromata minuta, inconspicua, rotundata, 0.4–0.8 mm. diam., atra, in epiphyllo leniter arcuata, in hypophyllo vix visibilia, dispersa, non connata; loculi singuli, in mesophyllo centraliter insidentes, globosi vel fere globosi, 480–670 μ in diam., supra clypeo atro, crasso, loculum non superanti praediti, stromate incrassato, atro circumdati; asci longe cylindracei, octospori, 95–110 x 7–8 μ; sporae monostichae, continuae, hyalinae longe fusiformes, 12–14 x 4–5 μ; paraphyses praesentes.

Stromata minute, inconspicuous, circular, 0.4–0.8 mm. in diameter, black, slightly convex in the epiphyll, scarcely perceptible in the hypophyll, scattered, not coalescing; locule single, centrally located in the mesophyll, globose or approximately so, 480–670 μ in diameter, with a thick black clypeus above, not exceeding the locule, and heavy black stroma all around; asci long-cylindrical, 8-spored, 95–110 x 7–8 μ, with the spores uniseriate; spores 1-celled, hyaline, long-fusoid, 12–15 μ; paraphyses present.

On *Exostema* sp., Las Caobas, San José de Ocoa, *Chardon 781*, July 10, 1937 (**type**).

Phyllachora gratissima Rehm, Hedwigia **31:** 306. 1892.

The type is from Baños, Ecuador, collected by Lagerheim, in 1891. This is a well-known, conspicuous species, forming large, tar-like spots, 2–3 mm. in diameter, on the upper surface of the leaves of the avocado. It is common in the higher elevations in Puerto Rico and in the subtropical zone of the Andes of Venezuela and Colombia. The fungus seems to be restricted to the humid subtropical zones. Our collection from the Dominican Republic is not an exception to this rule.

On *Persea gratissima* L., Prov. La Vega, trail from Jarabacoa to Constanza, 600 m., *Chardon 1143*, Sept. 13, 1937; Constanza Valley, 1150 m., *Chardon 1170*, September 15, 1937.

Phyllachora insueta Sydow, Ann. Mycol. **23:** 372. 1925.

The species was originally described from material collected in Grecia, Costa Rica, on *Serjania caracasana* and distributed under Sydow's *Fungi exot. exs. 662*. Also known from various collections made by the writer in Venezuela and Colombia.

The stromata in the Dominican material are typical: pustule-like, raised above the leaf epidermis, yellowish-green, dotted with minute, black specks, which are the clypei of the locules. In cross section, the locules are numerous, labyrinthiform, with the leaf tissue hypertrophied around the locules. The spores are ellipsoidal, uniseriate, 15 x 6 μ. This is the first report of the fungus from the West Indies.

On *Serjania* sp., Prov. Samaná, Savanas, near Sabana la Mar, *Chardon 709*, July 5, 1937.

Phyllachora Masini Toro, Sci. Survey Porto Rico & Virgin Isl. **8** (1): 53. 1926.

The type specimen is from the mountains above Yauco, Puerto Rico, *Whetzel, Kern & Toro 2482*. The spots are black, circular, 1–2 mm. in diameter, more conspicuous in the epiphyll, bordered by a reddish zone of host tissue. The shape and measurement of the asci and spores agree with the type material.

On *Brunellia comocladifolia* H. & B., Prov. La Vega, trail from Constanza to Valle Nuevo, 1575 m., *Chardon 1181*, Sept. 16, 1937.

Phyllachora ocoensis Chardon sp. nov.

FIGURES 18–21

Stromata amphigena, parva, punctiformia, atra, rotundata, 0.5–1.0 mm. in diam., in hypophyllo convexa, in epiphyllo tantum leniter elevata; loculi singuli, globosi, 300–360 x 250–278 μ, ostiolo parvo epidermidem versus muniti, undique (praesertim infra supraque) membrana stromatica atra cincti; asci cylindrico-clavati, octospori, 95–110 x 17–19 μ; sporae distichae vel in asco aggregatae, continuae, hyalinae, longe naviculares, 17–23 x 4.5–6.0 μ, plasmate granuloso, homogeneo; paraphyses praesentes.

Stromata amphigenous, small, punctiform, black, circular, 0.5 to 1.0 mm. in diameter, convex in the hypophyll, only slightly raised in the epiphyll; locule single, globose, 300–360 x 250–278 μ, with a small beak facing the epidermis, surrounded on all sides (especially above and below) with black, stromatic tissue; asci cylindrical-clavate, 8-spored, 95–110 x 17–19 μ, with the spores biseriate or crowded in the ascus; spores 1-celled, hyaline, long-navicular, 17–23 x 4.5–6.0 μ, with the contents homogeneous; paraphyses present.

This small *Phyllachora* macroscopically resembles *Ph. Acaciae* P. Henn., a species of wide distribution in tropical America, but the stromata are more conspicuous. In *Ph. Acaciae* they do not reach 0.5 mm. in diameter. The spore characters are also different (in *Ph. Acaciae* they are 14–16 x 5 μ). A cross section of the leaf of our material shows that the base or bottom of the locule is in the hypophyll, where it bulges out conspicuously, while the upper portion of the locule has a small neck which faces the epiphyll.

On leguminous shrub (with pinnate leaves), Las Caobas, road to San José de Ocoa, *Chardon 773*, July 10, 1937 (**type**).

Phyllachora Ocoteicola Stevens & Dalbey, Bot. Gaz. **68**: 57. 1919.

Our material has been compared with the type specimen, *Stevens 4768*, from Monte Alegrillo, Puerto Rico. In the original diagnosis the spores are described as "oblong to cylindrical, 17–54 μ, somewhat pointed at one end." This is a gross typographical error. We have reexamined the type, as well as *Stevens 1520*, also from Puerto Rico, and they are 14–20 x 5–7 μ, with one end tapering.

In the specimen from the Dominican Republic, the stromata are black, shiny, angular, 2–3 mm. across, surrounded by a zone of dead host tissue, characters which compare well with the Puerto Rico material. The spores are 17–21 x 7–8 μ, a trifle larger, pointed at one end.

On *Ocotea* sp., Prov. La Vega, Constanza Valley, 1150 m., *Chardon 1175*, Sept. 14, 1937.

Phyllachora panamensis Stevens, Ill. Biol. Monogs. **11** (2): 37. 1927.

FIGURES 22–27

The type material is *Stevens 1351*, Fungi of Panama. Our Dominican material compares well with it in macroscopic characters, in the size and shape of the asci, and in the ellipsoidal spores 15–17 x 6–8 μ, which are arranged uniseriately in the ascus. It has also conidia which are small, globose to elliptical, about 2 μ long. Our specimen is not *Phyllachora Roureae* Sydow from the Philippines, the description of which was based on conidial material (Philippine Jour. Sci. **8** (4) sec. C: 227. 1923), distributed as *Sydow's Fungi exot. exs. 187*. We have examined this material and it has filiform conidia (stylospores) which measure 24–46 x 1–1.5 μ. (See fig. 26.)

On *Rourea glabra* H.B.K., Prov. La Vega, near Maimón, *Chardon 1064*, Aug. 13, 1937.

Phyllachora Phaseoli (P. Henn.) Theiss. & Sydow, Ann. Mycol. **13:** 507. 1915.

The type, *Physalospora Phaseoli* P. Henn. from Brazil, has not been examined, but our material has been compared with numerous specimens from Puerto Rico and with Sydow's *Fungi exot. exs. 667*, from San José, Costa Rica. The stromata are typical: punctiform, minute, in dense circular groups; the spores are 9–12 x 6–8 μ, broad-elliptical.

On *Phaseolus lunatus macrocarpus*, Hato del Yaque, *Ciferri 4842*, Feb. 7, 1932; on *Phaseolus* aff. *adenanthus*, road from Santiago to Puerto Plata, *Ciferri 4575*, Feb. 5, 1931; on *Phaseolus* sp., Dist. Nacional, ravine at Km. 30, Duarte Road, *Chardon 677*, June 30, 1939.

Phyllachora Scleriae Rehm, Hedwigia **39:** 232. 1900.

Originally described from South America. A common species in Puerto Rico, on *Scleria*; also known from Panama City (*Chardon & Nolla 188*). Spores long-fusiform, 19–21.5 x 5 μ. Probably present in other West Indian islands.

On *Scleria pterota* Presl., Prov. Trujillo, Sabana de Guabatico, north of Guerra, *Chardon 553*, June 20, 1937; Dist. Nacional, ravine at kilometer 30, Duarte Road, *Chardon 678*, June 30, 1937.

Phyllachora viequesensis Orton & Toro, Sci. Surv. Porto Rico & Virgin Isl. **8** (1): 54. 1926.

Stromata typical of the Phyllachoraceae on grasses and sedges, several loculate (mostly 2–3), the stromata formed in large air cavities beneath the epidermis of the host. Spores obliquely uniseriate, long-fusiform, 18–20 x 6 μ; paraphyses present. Our material has been compared with type material, *Whetzel, Kern & Toro 2648*, on the same host, from Vieques Island, Puerto Rico.

On *Cyperus ligularis* L., Prov. Samaná, beach at Sabana la Mar, *Chardon 688*, July 4, 1937; Prov. Barahona, shores of Lake Rincón, near Cabral, *Chardon 796*, July 11, 1937.

Phyllachora Paspalicola P. Henn., Hedwigia **48:** 106. 1908.

Common throughout tropical America, where the host plant is widely distributed. Spores lemon-shaped, 8–10 x 5–6 μ.

On *Paspalum conjugatum* Berg., Prov. Trujillo, San Cristobal, *Kern & Toro 156*, Mar. 12, 1926; Prov. Azua, Las Caobas, San José de Ocoa, *Chardon 779*, July 10, 1937; Puerto Plata, ravine at Km. 37, road to Puerto Plata, *Chardon 914*, Aug. 1, 1937; Prov. La Vega, ravine, base of Loma Peguera, *Chardon 1059*, Aug. 13, 1937.

Rhagadolobium cucurbitacearum (Rehm) Theiss. & Syd., Ann. Mycol. **12:** 275. 1914.

Spots conspicuous, in the undersurface of the leaf, appearing like dusted gunpowder. Reported from various Tropical American countries.

On *Gurania* sp., Prov. La Vega, trail from Jarabacoa to Constanza, 1100–1300 m., *Chardon 1145*, Sept. 14, 1937.

FIMETARIALES

Sordaria curvula De Bary, Morph. Phys. Pilze p. 209. 1866.

On cow dung, Prov. Azua, river forest, near San Juan de la Maguana, *Chardon 623*, June 27, 1937.

SPHAERIALES

Melanopsamma Milleri Chardon sp. nov.

FIGURES 5–8

Perithecia superficialia, atra, carbonacea, fere 0.8 mm. in diam., 0.1 mm. alta, hemisphaericalia usque conoidea, levia, non nitentia, Rosellinia similis, in strato ligneo subimmersa, ostiolo distincto papilliformi praedita; muro perithecii duplici, e pariete exteriore duro, carbonaceo, et interiore molli, brunneo composito; asci cylindracei, breviter pedicellati, maximi, 170–210 x 12–17 μ, apice et basi membrana tenui pseudoparenchymatica e paraphysoideis composita tunicati, octospori; sporae ex parte distichae in asco dense compressae, uniseptatae, hyalinae, longe fusiformes, interdum subarcuatae, ad septum constrictae, magnae, 59–64 x 9–12 μ, leves, utrinque acutae; paraphysoidea filiformia.

Perithecia superficial, black, carbonaceous, about 0.8 mm. in diameter, 1.0 mm. in height, hemispherical to conical, with the surface smooth, not shiny (*Rosellinia*-like), seated on the woody substratum where they are slightly immersed, and provided with a pronounced papilliform ostiolum; perithecial wall made up of a double wall, the outer hard, carbonaceous, and the inner brown and soft; asci cylindrical, short-pedicellate, very large, 170–210 x 12–17 μ, embedded in paraphysoids that are connected with a fine pseudoparenchymatous tissue on the top of the perithecium and a similar one at the base, 8-spored, with the spores partially biseriate, closely pressed in the ascus; spores 1-septate, hyaline, long fusiform, sometimes slightly arcuate, constricted at the septum, large, 59–64 x 9–12 μ, smooth, with the ends acute; paraphysoids filiform.

A beautiful species, picked up for a *Rosellinia*. The conspicuous black perithecia are seated on the woody matrix with no subiculum or stroma. The species is dedicated to Dr. Julian H. Miller, of the University of Georgia, a distinguished student of the Sphaeriales, who confirmed the determination of the fungus as a new species and its inclusion under *Melanopsamma*.

On dead wood, La Vega, forests at El Hatillo, near Yuna river, *Chardon 1094*, Aug. 28, 1937 (**type**).

Lasiosphaeria pezizula (Berk. & Curt.) Sacc. Syll. Fung. **2:** 195. 1883.
Sphaeria pezizula Berk. & Curt., Grevillea **4:** 106. 1875.

Previously known from Puerto Rico, Bermuda, and continental North America. (Determination made by Professor H. M. Fitzpatrick.)

On dead wood, La Vega, near Jarabacoa, *Chardon 1229*, Sept. 13, 1937.

Calyculosphaeria calyculus (Mont.) Fitzpatrick, Mycologia **15:** 51. 1923.
Sphaeria (*Caespitosa*) *calyculus* Mont., Ann. Sci. Nat. ser. II, **14:** 322. 1840.
Sphaeria calyculus Mont., Syll. Crypt. p. 226. 1856.

For more details of this interesting species see Fitzpatrick (*l.c.*). The type is from French Guiana, collected by Leprieur. (Determined by Dr. J. H. Miller.)

On decaying fence posts, La Vega, Maimón River, near Maimón, *Chardon 1009*, Aug. 13, 1937.

Leptosphaeria Cecropiae Chardon sp. nov.

Maculae amphigenae, epiphyllae parvae, rotundae, 1.0–1.5 cm. in diam., centro peritheciis aggregatis atratae, hypophyllae pustulatae, parvae, argenteae ut colore folii, ostiolis peritheciorum minute punctulatae; perithecia pluria, 5–12, in quaque macula, lageniformia, 240–300 x 215–270 μ, pariete brunnea praedita; asci cylindracei, 175–190 x 12–14 μ, octospori; sporae oblique monostichae, longe fusoideae, clare brunneae, 3-septatae, ad septa constrictae, una cellula terminali attenuata; paraphyses filiformes, numerosissimae.

Spots amphigenous, in the epiphyll appearing as small, circular, brown spots, 1–1.5 cms. in diameter, with the center black due to the coalescing perithecia; in the hypophyll pustule-like, small, of the same silver color as the leaf, but showing minute black spots which are the necks of the perithecia; perithecia several (5–12) on each spot, flask-like in section, 240–300 x 215–270 μ, provided with a brown wall; asci cylindrical, 175–190 x 10–14 μ, 8-spored, with the spores obliquely uniseriate in the ascus; spores long-fusoid, distinctly brown, 3-septate, constricted at the septa and one end cell tapering; paraphyses filiform, very abundant.

Macroscopically, the pustule-like spots which appear on the undersurface of the leaf are typical. Both the asci and spores show beautifully under the microscope.

On *Cecropia peltata* L., Kilometer 67, near La Cumbre, road to Bonao, *Chardon & Toro 832*, July 11, 1937 (**type**).

Leptosphaeria Smilacis Chardon sp. nov.

Maculae magnae, in utraque pagina folii visibiles, conspicuae, orbiculares vel ellipticae, plus minus 1.0 cm. in diam., vel confluentes et majores, subalbae, peritheciis numerosis minutis punctatae, e zona atra definita marginatae; perithecia minuta, in textura matricis immersa, globosa, 145–170 μ in diam., pariete definito e cellulis brunneis composito, non-ostiolata; asci cylindrico-clavati, octospori, parvi, 47–55 x 8–9 μ, in stipitem brevissimum contracti; sporae irregulariter conglobatae, brunneae, 3-septatae, longe fusiformes, subcurvatae, 14–19 x 4–5 μ; paraphyses praesentes.

Spots large, visible on both surfaces of the leaves of the host, conspicuous, circular, or elliptical, about 1 cm. in diameter or larger through coalescence, whitish, with numerous minute specks (perithecia) in the

spot, provided with a definite blackish margin; perithecia small, immersed in the host tissues, globose, 145–170 μ in diameter, with a definite cell wall made up of brown cells, without a beak; asci cylindrical-clavate, 8-spored, small 47–55 x 8–9 μ, short-stipitate, with the spores inordinately pressed together; spores brown, 3-septate, long-fusiform, slightly curved, 14–19 x 4–5 μ; paraphyses present.

The spots produced by this fungus are very conspicuous on both surfaces of the leaves of the host, with many minute specks and a definite border. The asci are clearly seen under the microscope with the brown, 3-septate spores tightly pressed together.

On *Smilax* sp., Distrito Nacional, road from Ciudad Trujillo to Bocachica, *Chardon 539*, June 13, 1937 (**type**).

Didymosphaeria Trichostigmae Chardon sp. nov.

Maculae amphigenae, brunneae, fere orbiculares, 2–4 mm. in diam., margine indefinita cinctate; perithecia in maculis densiuscule (6–13) disposita, semper epiphylla, inconspicua, punctiformia, globosa, parva, 210–280 x 160–175 μ, pariete cellulari definito, circa ostiolum incrassato et obscuriore praedita; asci numerosi, fasciculati, cylindracei, octospori, 95–133 x 8–10 μ; sporae inordinatae, bicellulares, elongatae, brunneae, ad septa constrictae, 28–34 x 3–4 μ; paraphyses praesentes.

Spots amphigenous, light brown, approximately circular, 2–4 mm. in diameter, with the margins indefinite; perithecia crowded in the spots (6–15 in number), visible only in the epiphyll, inconspicuous, punctiform, globose, small, 210–280 x 160–175 μ, provided with a definite, brown, cellular perithecial wall, which thickens around the region of the ostiolum and becomes dark brown, the numerous asci fasciculate inside the perithecium; asci cylindrical, 8-spored, 95–135 x 8–10 μ, with the spores inordinate; spores 2-celled, long rod-like, brown, constricted at the septum, 28–34 x 3–4 μ; paraphyses present.

This is different from *Linospora Trichostigmae* Stevens, described on the same host from Puerto Rico. In Clements and Shear (3, p. 68), there are two genera in the Sphaeriaceae-Phaeodidymae which have close perithecial characters: *Stegastroma*, with a clypeus, and *Didymosphaeria* without a clypeus. Our specimen has no clypeus; the brown tissue occurring around the region of the ostiolum is produced by a thickening of the perithecial wall. Although the walls of this perithecial neck attains a thickness of 50–60 μ, it neither loses its cellular structure, nor becomes black, and hence cannot be interpreted as a clypeus. The asci inside the perithecia are basal-peripheral which fits with *Didymosphaeria*.

On *Trichostigma octandrum* (L.) H. Walt., Duarte, road to San Francisco de Macoris, *Chardon & Toro 853*, July 11, 1937 (**type**).

Metasphaeria phyllachoracearum Petrak, Ann. Mycol. **29:** 350. 1931.

Telimena domingensis Chardon, Jour. Dept. Agric. Porto Rico **13:** 14. 1929.

The specimen cited below, *Kern & Toro 156*, was studied by the writer in 1929 (*l.c.*) and described as a new species of *Telimena*, on the basis of the spores being "fusoid, 3-septate, hyaline to greenish, with both ends acute, 12–14 x 2–3 μ."

The researches of Dr. F. Petrak (Mykologische Notizen, XI, *l.c.*) have thrown new light on this fungus. He did not see the type material, but from examination of other material made available to him by Dr. R. Ciferri, he concluded there was no *Telimena*, and that the asci and 3-septate, hyaline, fusoid spores were the ascosporic stage of a *Metasphaeria* parasitic on the stromata of certain Phyllachoraceae. A reexamination of the type of *Telimena domingensis* Chardon has convinced the writer that he was in error, and that Petrak's interpretation is the correct one.

On old phyllachoroid stromata on *Paspalum conjugatum* Berg., San Cristobal, *Kern & Toro 156*, March 12, 1926.

Pleospora Doidgeae Petrak, Ann. Mycol. **25:** 295. 1927.

Dictyochorella Andropogonis Doidge, Bothalia **1:** 66. 1921.

The synonymy of these two species was clearly established by Petrak (*l.c.*). The type of Miss Doidge's species is on *Andropogon nardus* from Natal, South Africa. The species was found in Venezuela by the writer, parasitic on various phyllachoroid stromata, and careful drawings were made. (See Monogr. Univ. Puerto Rico, Ser. B, No. **2,** *plate XXXI, figs. 2–3*, 1934.)

In the material from the Dominican Republic the perithecia are found inside or adjacent to old phyllachoroid stromata; they are clearly provided with a brown, cellular, perithecial wall; asci 65–85 x 8–10 μ, 8-spored, with the spores inordinate; spores muriform, brown, with one of the central cells longitudinally septate, 17–19 x 5–6 μ. This leaves no doubt as to the identity of the species, which is the first record of its occurrence in the West Indies.

On old phyllachoroid stromata, on *Andropogon bicornis* L., Distrito Nacional, ravine al Kilometer 30, along Duarte Road, *Chardon 672*, June 30, 1937.

FUNGI IMPERFECTI

Phyllosticta Citharexyli Chardon sp. nov.

Maculae amphigenae, conspicuae, fere orbiculares vel irregulares, 4–7 mm. in diam., zona decolorata membranae matrici emortuae, e pycnidiis numerosis atris punctata compositae, margine definita, conspicua, leniter elevata rubro-violacea circumdatae; pycnidia globosa vel subglobosa, in membrana folii epiphyllum versus immersa, parva, 93–120 x 72–81 μ, cellulis definitis composita; conidia unicellularia, hyalina, ovata, 8–9 x 5–7 μ.

Spots amphigenous, conspicuous, approximately circular or irregular in outline, 4–7 mm. in diameter, made up of a discolored zone of dead host tissue in which may be seen numerous small, black specks (the pycnidia), the dead tissue being surrounded by a definite, conspicuous, slightly raised margin of reddish violet tissue; pycnidia globose or nearly so, immersed in the tissues of the leaf, facing the epiphyll, small, 93–120 x 72–81 μ, made up of distinct wall cells; conidia 1-celled, hyaline, ovate in shape, 8–9 x 5–7 μ.

On *Citharexylon* sp., Prov. Samaná, *Chardon 744*, July 6, 1937 (**type**); Prov. Santiago, San José de las Matas, *Chardon 483*, June 6, 1937.

Phyllosticta Stigmatophylli Chardon sp. nov.

Maculae fere orbiculares vel irregulares, amphigenae, 2–4 mm. in diam., epiphyllae subalbae, centro pycnidiis numerosis laxe dispersis punctatae, linea definita, parum elevata cincta, hypophylla sordide brunneae, sine linea definita; pycnidia dispersa, immersa, globosa, 110–125 μ in diam., non-ostiolata, semper epiphylla; conidia hyalina, unicellularia, ovoidea usque ellipsoidea, 7–9 x 5–6 μ, numerosissima.

Spots nearly circular or irregular in outline, amphigenous, 2–4 mm. across, whitish in the epiphyll, with numerous specks (pycnidia) scattered in the center of the spot, with a slightly elevated, definite black margin which makes the spot conspicuous; in the hypophyll the spots are dirty black in color, without a pronounced border; pycnidia scattered over the infected spot, immersed globose, 110–125 μ in diameter, not beaked, restricted to the upper side of the leaf; conidia hyaline, 1-celled, ovoid to ellipsoidal, 7–9 x 5–6 μ, very numerous.

On *Stigmatophyllon* sp., Prov. Santiago, San José de las Matas, *Chardon 494*, June 6, 1937 (**type**).

Cylindrosporium Securidacae Chardon sp. nov.

Maculae amphigenae, angulares, parvae, 1.0–1.5 mm. in diam., centro brunneae, margine obscuriore, parum elevato cinctae; acervuli subepidermicales, 100–120 μ in diam.; conidia unicellularia, hyalina, longe bacillaria, arcuata, 17–25 x 3 μ, plasmate homogeneo, in conidiophoris hyalinis acutis oriunda.

Spots amphigenous, angular, small, 1.0–1.5 mm. across, brown in the center, with a slightly raised dark margin; acervuli subepidermal, 100–120 μ across; conidia 1-celled, hyaline, long rod-like, curved, 17–25 x 3 μ, with the contents homogeneous, borne on hyaline tip-like conidiophores.

On *Securidaca volubilis*, Prov. Samaná, beach at Sabana la Mar, *Chardon 695*, July 4, 1937 (**type**).

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REPÚBLICA DOMINICANA

LITERATURE CITED

1. **Berkeley, M. J.** Enumeration of some fungi from Santo Domingo. Ann. Mag. Nat. Hist., ser. II, **9:** 192–203. 1852.
2. **Ciferri, R.** Micoflora Domingensis. Est. Agron. Moca (Républica Dominicana) Ser. B, No. **14:** 1–260. 1929.
3. **Clements, F. E. & C. L. Shear.** The Genera of Fungi. 496 p. Wilson Co. New York. 1931.
4. **Seaver, F. J. & C. E. Chardon.** Mycology *in* Scientific Survey of Porto Rico and Virgin Islands, **8** (1): 1–208. 1926.

EXPLANATION OF FIGURES

Figs. 1–4. *Nymanomyces Xolismae* sp. nov.

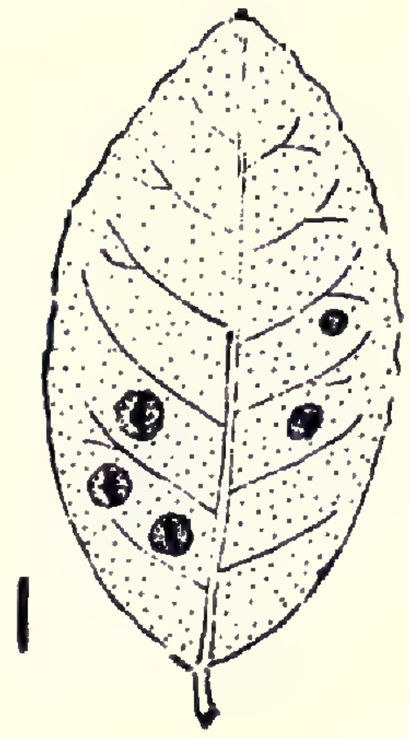
1. Leaf of *Xolisma* sp. showing hypophyllous ascoma opening by a longitudinal slit.
2. Cross section of leaf of ruptured ascomata in the hypophyll disclosing the hymenium and epiphyllous sterile stromata.
3. Portion of the hymenium with asci and numerous paraphyses.
4. Individual ascospores.

Figs. 5–8. *Melanopsamma Milleri* sp. nov.

5. Perithecia, natural size.
6. Perithecia under binocular, showing papilliform ostiolum; seated and partially immersed in the woody matrix.
7. An ascus and two paraphyses.
8. Ascospore.

Figs. 9–13. *Dothidella domingensis* sp. nov.

9. Habitat sketch of fungus on leaves of *Baccharis myrsinites*.
10. Cross section of leaf showing position of compound stroma with several locules.
11. Ascus and spores.
12. Individual ascospores, showing septation, with one cell larger and obtuse, and the other cell smaller, with a subacute end (note that there is no thickening of the cell wall).
13. Individual ascospores of *Dothidella tinctoria* showing differences from the above (note the larger size, the ascospore divided into two cells of approximately the same size, and the thick cell wall).



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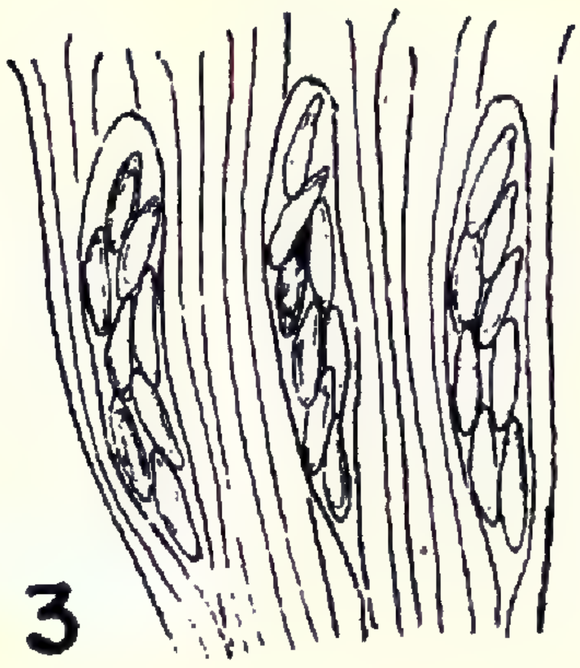

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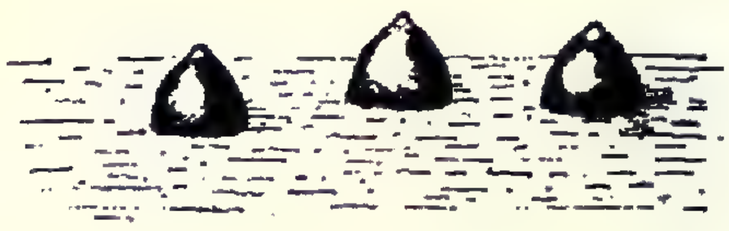

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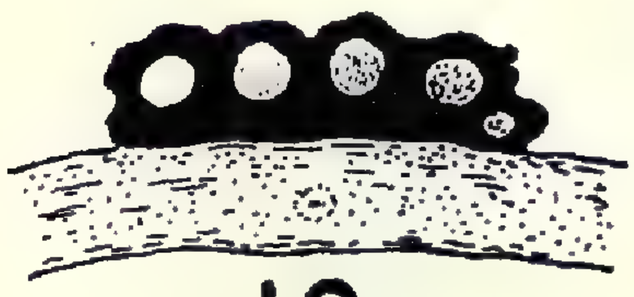

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Figs. 14–17. *Catacauma Sabal* sp. nov.

14. Habit sketch of fungus on a portion of a leaf of *Sabal* sp.
15. Cross section of leaf showing amphigenous, loculate, angular stromata located between the epidermis and the mesophyll.
16. Clavate ascus and paraphyses with ascospores inordinately pressed in the ascus.
17. Two ascospores.

Figs. 18–21. *Phyllachora ocoensis* sp. nov.

18. Habit sketch of pinnate leaves, leguminous shrub with small punctiform stromata.
19. Cross section of a pinna of the same with uniloculate stroma in the mesophyll.
20. Ascus and thread-like paraphyses.
21. Two individual ascospores.

Figs. 22–27. *Phyllachora panamensis* Stevens.

22. Habit sketch of fungus on leaves of *Rourea glabra*, showing angular stromata.
23. Cross section of leaf showing position of stromata and locules in the mesophyll.
24. Ascus and paraphyses.
25. Two individual ascospores.
26. Stylospores (*Phyllachora Roureae*).
27. Conidia (*Ph. panamensis*).

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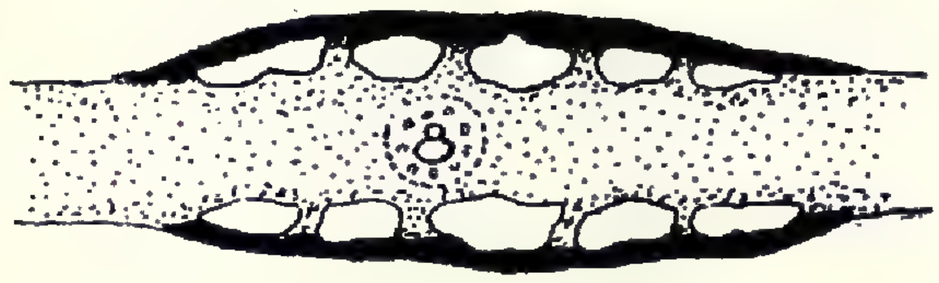
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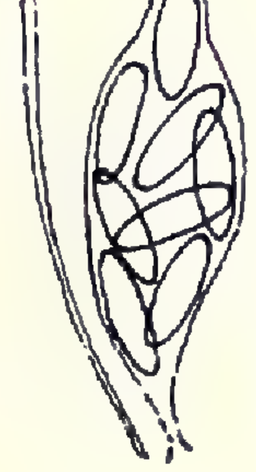
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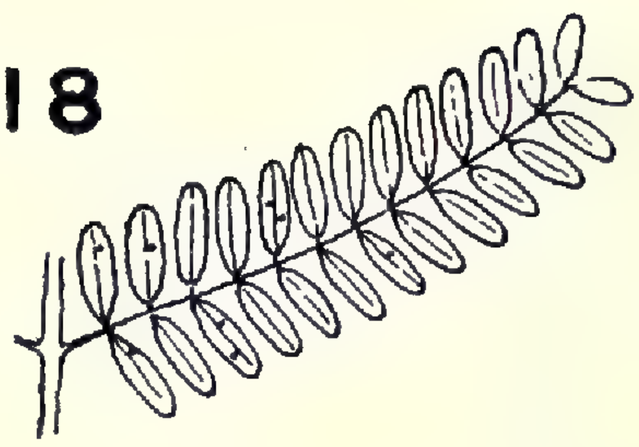
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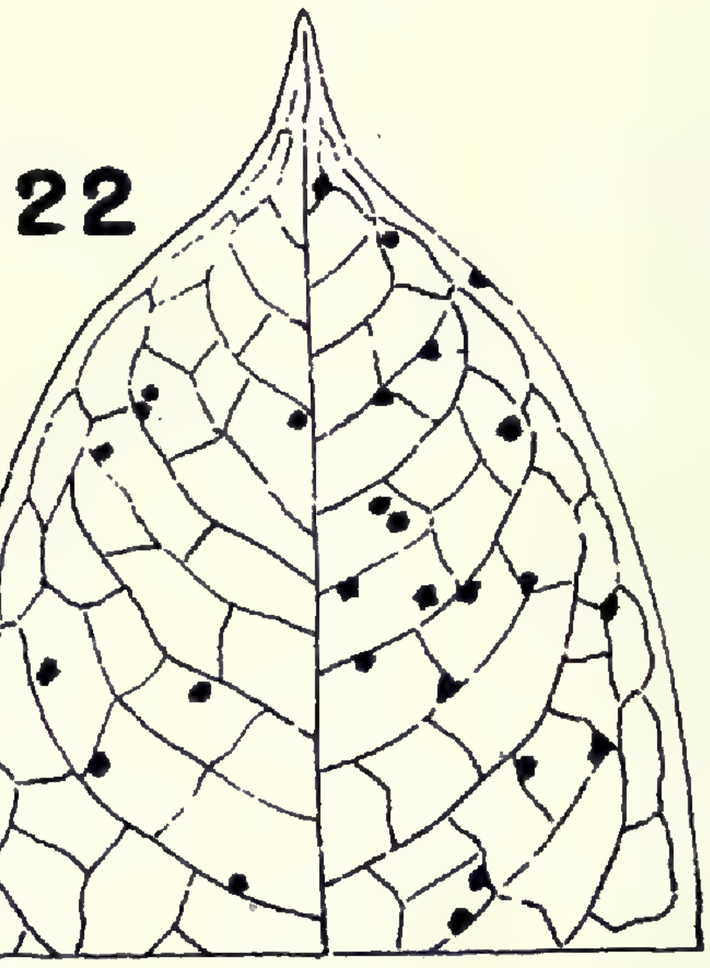
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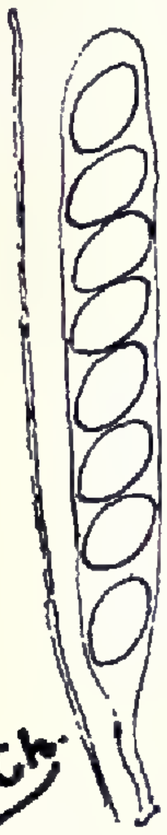
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2(4):475–525 FARLOWIA JULY, 1946

THE BIOLOGY OF GYMNOSPORANGIUM NIDUS-AVIS THAXTER

ALTON E. PRINCE [1]

HISTORICAL RÉSUMÉ

The history of our knowledge of *Gymnosporangium nidus-avis* Thaxter is varied and interesting. This has resulted from several circumstances. (1) The rust has proved to be heteroecious, and we now know that it affects many host species in both its aecial and telial phases. (2) The elucidation of its hosts has proceeded slowly, at times uncertainly. (3) The manifestations of the hosts carrying the telial phase are confusing, for while usually they are witches' brooms with juvenile, subulate leaves, in other instances they are brooms with adult, scale-shaped leaves, and in still others they are slight fusiform stem swellings or only simple twig, branch or stem infections. A still further complication is now added as a result of studies recorded in this paper which presents evidence that the heretofore recognized *G. juvenescens* Kern is not distinguishable from *G. nidus-avis*.

The history begins with two collections made by Ravenel along the Santee Canal, South Carolina, in the spring seasons of 1848 and 1850 respectively. These specimens are now a part of the Curtis collection in the Farlow Herbarium, and bear the original labels under the designation *Gymnosporangium Juniperi* Lk. About thirty years later Farlow (1880) called attention to them and decided that they were properly *G. conicum* DC.[2] Since Ravenel's time many collections of *G. nidus-avis* have been made and there are scores of references to this species in the literature, but the latter are of interest mainly from the standpoint of geographical distribution. This resumé, however, will be restricted to a brief survey of the taxonomic and biological contributions pertinent to the author's studies. Thus it includes only references to the works of Farlow, Thaxter, Arthur, Kern, and the few others who have made additions of some significance. In this connection, Farlow and Thaxter stand out as the pioneer contributors.

Farlow (1880) was actually the first to give a description of *G. nidus-avis*. This he did in his notable monograph on the Gymnosporangia of the United States. He described it as an American representative of the European *G. conicum* DC. on *Juniperus virginiana*, but he included specimens of this rust characterized only by fusiform stem swellings and pul-

[1] Thesis submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy at Harvard University.

[2] The *G. conicum* DC referred to by Farlow (1880, pp. 23–24) is in my judgment what is now known as *G. juniperinum* (L.) Mart.

vinate telia. In the same paper he made mention of rust brooms on *Juniperus virginiana*, but ascribed them to *G. clavipes* C. & P. The illustrations in his monograph (1880, *Pl. 2, figs. 22–27*), however, represent perfectly what Thaxter subsequently described under the name *G. nidus-avis*.

In a second paper, Farlow (1886a) stated that the broom rust on red cedar previously referred to by him as *G. clavipes* likewise produces its *Roestelia* on *Amelanchier*. The same year Farlow (1886b) confirmed the previous report that his *G. conicum* was the cause of brooms on *Juniperus virginiana*, although his cultures failed to produce aecia on *Sorbus* (one of the known hosts of *G. conicum* in Europe). In spite of this failure he was unshaken in his conviction that the rust was *G. conicum*, and he expressed the belief that additional cultures would demonstrate *Sorbus* to be a host. If this had been proven then to be the case, Thaxter probably would not have continued investigations which later led to the establishment of a new species.

The work of Thaxter is fundamentally significant because of its biological findings. He reported (1887) inoculations of Farlow's *G. conicum* on *Amelanchier canadensis*,[3] *Aronia arbutifolia*, *Sorbus americana* (*Pyrus americana*) and *Malus pumila* (*Pyrus Malus*). The *Amelanchier* only became infected, and on it were produced both spermogonia and aecia. As an indication of the extreme variability exhibited by this species, he noted that he was unable to distinguish the aecia from those of his *Roestelia lacerata y* (*G. globosum* Farl.) even though the former matured two months earlier than the latter. Thaxter (1889) reported two further series of cultures. In the first, inoculations were made on *Amelanchier canadensis*, *Crataegus coccinea*, *Malus pumila* (*Pyrus Malus*), and *Sorbus*. Again, only the *Amelanchier* became infected and, as before, both spermogonia and aecia were produced. The second series was restricted to cultures made on *Amelanchier*. Following these experiments he stated that the result was "similar in all respects to that obtained in previous years." From these investigations he reached the following significant conclusions: "In relation to our 'birds' nest' *Gymnosporangium*, the question of identities is still further confused by my cultures of this species, made during three successive years with identical results. The *Roestelia* obtained . . . was referred to *R. cornuta*, there being no other alternative among described American Roestelias. . . . It should be noted that upon *Sorbus* the 'birds' nest' *Gymnosporangium* has given no result whatever. Further careful cultures and observation together with a more extended examination of European specimens than I have been able to make, will of course be necessary to confirm this supposition; but I am decidedly of the opinion that our 'birds' nest' species is a distinctly American form as yet unnamed."

[3] The name *Amelanchier canadensis* should now be referred to *A. arborea* (Michx. f.) Fernald, and the name *A. oblongifolia*, in part, to *A. canadensis* (L.) Medic. Rhodora **43:** 559–567. 1941.

Two years later Thaxter (1891) published a description of the telial and aecial stages of the new species under the name *G. nidus-avis*. He also republished these descriptions in 1892 and 1893. Specimens of Thaxter's cultures of *G. nidus-avis* are in the Farlow Herbarium and have been carefully examined by me. The groundwork being thus firmly laid, it remained for others to confirm and extend it.

During the period between 1908 and 1915, Arthur (1908) reported inoculations on *Amelanchier intermedia*, and *Malus pumila* var. *Whitney Crab* (*Malus Malus* var. *Whitney Crab*). The apple plant only became infected. This produced both spermogonia and aecia on its leaves. In 1910 he reported on additional cultures made in 1909, when *Amelanchier canadensis*, *Crataegus Pringlei*, and *Malus ioensis* were inoculated. The *Malus* and *Crataegus* became infected, the former producing spermogonia and aecia, the latter spermogonia only. The *Amelanchier* remained uninfected. In his report of cultures made in 1910, he stated that the fruit of *Amelanchier ovalis* (*A. vulgaris*) and the leaves of *Cydonia oblonga* (*C. vulgaris*) and *Malus coronaria* were inoculated but only the *Amelanchier* became infected, and it produced spermogonia and aecia. A second series of inoculations was made later in the same year on identical specific hosts. That time the *Malus* alone became infected, but with the production of spermogonia only; the leaves died before aecia could be developed. Finally Arthur (1915) reported his last cultures of this rust. *Amelanchier ovalis* (*A. vulgaris*) was inoculated and both spermogonia and aecia were produced. Arthur (1934) in summary has recently listed the following names of plants that serve as hosts of *G. nidus-avis*: for the aecial stage — *Amelanchier canadensis*, *A. erecta*, *A. intermedia*, *A. laevis*, *A. oblongifolia*, *A. ovalis* (*A. vulgaris*), *Crataegus Pringlei*, *Cydonia oblonga* (*C. vulgaris*), *Malus pumila* (*Malus Malus*); for the telial stage — *Juniperus virginiana*.

Dodge was the next important contributor. His most notable work concerned teliospore formation and production, and this will be reviewed in the section below dealing with life history of the fungus. He also (1918b, pp. 294–295) published the results of cultures of *G. nidus-avis* made between 1914 and 1917. A species each of *Amelanchier* and *Malus* was inoculated in the spring of 1914 with inoculum from telia borne in the axils of leaves on brooms, from the stems of brooms, and from sori on the tree trunk. Some aeciospores from these cultures were used to inoculate a potted red cedar plant in June 1914. No external symptoms of infection appeared in 1915. Two small sori became evident in May 1916. By 1917 these two sori had coalesced and produced a telial mass two inches long. This infection spread vertically five inches in three years. On May 10, 1916 telia were collected in the field for inoculation purposes. The sowings were made on *Amelanchier "canadensis,"* May 17, and aecia were produced June 17. A cedar was inoculated with spores from this culture on June 21. On March 22, 1917, twenty-one days after being taken from a cold frame, a telium appeared in the axil of one leaf. The

next year, on February 19, 1918, two more sori appeared. Thus under favorable conditions telia may be produced the spring following inoculation. Dodge (1918c) thus found that telial sori of *G. nidus-avis* sometimes develop "on the blades of leaves." Dodge (1931) found that *G. nidus-avis* was very destructive to eastern red cedar trees. As emphasized by him, this is very much in contrast to the general belief that it is only the aecial host which is injured. According to him (1934) the common red cedar is subject to attacks by *G. nidus-avis* of such severity as to cause the premature death of the suscept.

As a matter of minor interest, reference may properly be made to Clinton and McCormick's (1924) Petri-dish cultures of *G. nidus-avis*. Leaves of *Cydonia oblonga* (*C. vulgaris*), *Malus ioensis* (*Pyrus ioensis*), *Malus pumila* (*Malus communis*), and *Malus pumila* var. *Wealthy* (*Pyrus Malus* var. *Wealthy*) were placed on a liquid medium in Petri-dishes and inoculated with basidiospores of the fungus. Spermogonia developed on the apple and quince leaves; aecia did not develop because of the unfavorable method of culture. The other inoculations gave negative results.

Prince and Steinmetz (1940) were the next to investigate *G. nidus-avis* when cultures of 1936 and 1937 were reported. In 1936, they inoculated *Amelanchier canadensis*, *A. laevis*, *A. stolonifera*, *A. canadensis* × *A. stolonifera*, *Malus pumila* var. *Wealthy* (*M.* sp. var. *Wealthy*); all except the apple became infected and produced spermogonia and aecia. In 1937 the plants inoculated were *Amelanchier canadensis*, *A. laevis*, *A. stolonifera*, *A. Wiegandii*, *A. canadensis* × *A. stolonifera*, *Cydonia oblonga* (*C. vulgaris*), *Chaenomeles japonica* (*Cydonia japonica*), *Malus* sp. and *Sorbus americana*; all of these except the *Chaenomeles*, *Malus* and *Sorbus* produced spermogonia and aecia. In addition to their culture experiments they made careful taxonomic comparison of the broom-forming rust of *G. juvenescens* on *Juniperus horizontalis*, with *G. nidus-avis* on *Juniperus virginiana*, making use of their cultures, field collections, and specimens obtained from various herbaria. No differences could be found in the spermogonial, aecial or telial stages of these rusts. Hence the morphological evidence clearly indicated that *G. juvenescens* differed in no respect from *G. nidus-avis*. But culture work was necessary before a final conclusion could be drawn. Should culture experiments confirm the tentative taxonomic conclusions of Prince and Steinmetz, the addition of *Juniperus horizontalis* as a telial host of *G. nidus-avis* is of greater significance than just the addition of another name to a host list. This is important because this telial host extends from the Atlantic nearly to the Pacific coast (see map p. 483) and this is a connecting link between the eastern and western red cedars, *Juniperus virginiana* and *J. scopulorum* respectively, (the latter being another recognized telial host of the so-called *G. juvenescens*).

The history of what, up until the present work, has been called *Gymnosporangium juvenescens* Kern will now be added to that of *G. nidus-avis*. Arthur (1907) reported the first cultures of the western rust, which at that time was determined as *G. Nelsoni* Arth. Telia from *Juniperus scopulorum*

were used as a source of inoculum for cultures which yielded spermogonia on *Amelanchier canadensis* and *Sorbus americana* but no aecia were formed. *Crataegus Pringlei*, *Chaenomeles japonica* (*Pyrus japonica*), and *Aronia melanocarpa* (*Aronia nigra*) were inoculated but no infection occurred. Arthur (1908) reported two series of cultures of "*G. Nelsoni*" later recognized by him to be *G. juvenescens*, using inoculum from *J. scopulorum*. In the first series, *Amelanchier intermedia* was inoculated and spermogonia appeared, but because of injury to the plant no further development took place. The second series was started about two weeks later using inoculum from a second collection of telia on *J. scopulorum*. Sowings were made on two plants of *Amelanchier canadensis* upon which were produced both spermogonia and aecia.

In regard to these cultures Arthur (1908) made the following statement: "The above results confirm and much extend the somewhat uncertain work of last season. It leaves no further doubt that *Roestelia Nelsoni* Arth. should be counted as a synonym of *G. Nelsoni* Arth. as suggested in the original publication of the name." This statement shows, more than anything else, the difficulty early investigators had in definitely placing the extremely variable species under consideration, since *G. Nelsoni* today is a valid species.

Arthur (1909) reported additional cultures of his "*G. Nelsoni*" using inoculum from the usual source. *Amelanchier erecta* and *Sorbus americana* were inoculated and spermogonia were produced on both hosts, but aecia only on the *Sorbus*. Arthur (1912a) reported the last cultures of this "*G. Nelsoni*" which were conducted during the spring of 1910. The inoculum used was obtained from *Juniperus virginiana*, and *Amelanchier erecta*, *Cydonia oblonga* (*C. vulgaris*) and *Malus coronaria* were inoculated. *Amelanchier* was the only host successfully infected and on it were produced spermogonia and aecia. Arthur (1912b) called attention to the fact that previous cultures reported under *G. Nelsoni* should be referred to *G. juvenescens* Kern.

Kern (1911) described the aecial and telial stages of a broom-forming rust on *Juniperus scopulorum* and *J. virginiana* under the name of *G. juvenescens*. As aecial hosts he cites *Amelanchier alnifolia*, *A. florida*, *A. oreophila*, *A. polycarpa*, and *A. pumila*. The distribution of the new species is given as "British Columbia and Alberta southeast to the Black Hills of South Dakota and to Colorado, and locally in Nebraska and Wisconsin."

Arthur (1934) subsequently gave a similar description and range of *G. juvenescens*. A number of hosts were added. For the spermogonial and aecial phases are given *Amelanchier alnifolia*, *A. Bakeri*, *A. canadensis*, *A. florida*, *A. humilis*, *A. Jonesiana*, *A. mormonica*, *A. oreophila*, *A. polycarpa*, *A. pumila*, *A. spicata* and *Sorbus americana*; as telial hosts *Juniperus horizontalis*, *J. scopulorum* and *J. virginiana*.

According to hitherto apparently unpublished data found on specimens and in letters now in the Farlow Herbarium, the late Dr. J. J. Davis likewise carried out cultures with *G. juvenescens* in 1918. It was he who

first recognized that brooms on *Juniperus horizontalis* were the result of a rust infection. Using inoculum from this source, sowings were made on *Amelanchier oblongifolia* on which both spermogonia and aecia were produced.

Fraser (1925) inoculated *Amelanchier alnifolia* with spores of *G. juvenescens* collected on *Juniperus horizontalis*. Spermogonia and aecia developed.

During the spring of 1935, Steinmetz and Hilborn (Prince and Steinmetz, 1940) using inoculum from *J. horizontalis*, which had previously been determined as *G. juvenescens* by Dr. J. C. Arthur, inoculated an undetermined species of *Amelanchier* which resulted in the production of spermogonia and aecia. They were unable to differentiate what was supposed to be *G. juvenescens* by cultures from *G. nidus-avis* made on the same *Amelanchier* plant. Prince and Steinmetz (1940) reported cultures made in 1936 and 1937 with inoculum from *Juniperus horizontalis* on *Amelanchier canadensis*, *A. canadensis* × *A. stolonifera*, *A. laevis*, *A. stolonifera*, *A. Wiegandii*, *Chaenomeles japonica* (*Cydonia japonica*), and *Cydonia oblonga* (*C. vulgaris*). Spermogonia and aecia were produced on all of these hosts except *Chaenomeles japonica*. The aecia produced were in all respects the same as those produced in parallel cultures of *G. nidus-avis*. It should be noted that the *Cydonia* was successfully inoculated because this host genus was not known previously as a host for *G. juvenescens* but was for *G. nidus-avis* and had served until then as one of the reasons which justified separating *G. juvenescens* from *G. nidus-avis*.

In consideration of the conflicting evidence presented by previous investigators, it has seemed desirable not only to study further the life histories of *G. nidus-avis* and the fungus called *G. juvenescens*, but also to make additional extensive inoculations in order to verify and add to, as far as possible, the work of these investigators. Thus the present studies were carried out with the hope of adding to the knowledge of the life history of the organism.

TAXONOMY

The nomenclature of *Gymnosporangium nidus-avis* Thaxter is probably less complicated than any other of the widely distributed North American species belonging to this genus. This is certainly not because of the uniformity of symptoms produced by the fungus since no species of *Gymnosporangium* other than *G. nidus-avis* causes more than one distinct type of fasciation of its telial host and in addition produces a variety of symptoms on the branches and stems. In the aecial phase it is very similar to several species occurring on the same aecial hosts, an example of which was given by Thaxter (1889), when he pointed out the uncertainty of distinguishing *G. nidus-avis* and *G. clavariaeforme* by gross appearance alone. This and other similarities are in part the cause of the not infrequent mislabeling of collections found in herbaria. Therefore it can

be said that the present simplicity in the nomenclature of this species is undoubtedly because of the thoroughness with which it was studied prior to its publication by Thaxter, and to the completeness and accuracy of his first description (1891). The following binomials have been applied to the rust now known as *Gymnosporangium nidus-avis* Thaxter. The phase in the life cycle to which the name was affixed is indicated by the Roman numeral at the left.

III **Gymnosporangium nidus-avis** Thaxter, Bull. Conn. Agr. Exp. Sta. **107:** 6. 1891.

III *G. clavipes* C. & P. *sensu* Farlow, Anniv. Mem. Bost. Soc. Nat. Hist. pp. 21–22. pl. 2, figs. 22–27. 1880.

III *G. conicum* Hedw. f. in DC. Flora Franc. *sensu* Farlow, Anniv. Mem. Bost. Soc. Nat. Hist. pp. 23–24. 1880.

O, I *Roestelia nidus-avis* Thaxter, Bull. Conn. Agr. Exp. Sta. **107:** 6. 1891.

III *Puccinia nidus-avis* (Thaxt.) O. Kuntze, Rev. Gen. Plant. **3:** 507. 1899.

III *Tremella nidus-avis* (Thaxt.) Arthur, Proc. Ind. Acad. Sci. **1900:** 136. 1901.

O, I *Aecidium nidus-avis* (Thaxt.) Farlow, Bibl. Index **1:** 68. 1905.

III *Gymnosporangium juvenescens* Kern, Bull. N.Y. Bot. Gard. **7:** 448. 1911.

The reasons for including *G. juvenescens* Kern as a synonym of *G. nidus-avis* will be presented in the sections to follow.

Crowell (1940) considered *G. effusum* Kern to be synonymous with *G. nidus-avis*, and thus has introduced a problem that must be dealt with. The writer has spent much time searching for *G. effusum* in South Carolina but has not been successful. However, the type material of *G. effusum* from the Arthur Herbarium has been very carefully examined and no close resemblance could be found between its telia and those of *G. nidus-avis*. In *G. effusum* the telia are elongate, broadly wedge-shaped, furcate, and according to Kern (1911) may become lacunose. In addition, the teliospores are very long, narrow, without an obvious constriction at the septum, and with no evidence of a slightly enlarged apex of the pedicel, characters which exclude this species from *G. nidus-avis*. To the writer, *G. effusum*, in its telial phase, is more closely related to the European *G. Sabinae* (Dicks.) Wint. than to any American species. Furthermore, preliminary cultures of *G. effusum* reported by Arthur (1912b) show that one alternate host is *Aronia*, and to check this many inoculations were made without success with *G. nidus-avis* on the known species and some varieties of *Aronia*. Therefore, because of the distinctive morphology of the two fungi and because of the differences in host ranges, it is not possible to include *G. effusum* as a synonym of *G. nidus-avis*. My own description of *Gymnosporangium nidus-avis* follows:

Spermogonia epiphyllous, hypophyllous or amphigenous, sometimes fructicolous, rarely caulicolous in yellowish, yellowish-orange or orange-yellow lesions, appearing on an average of twelve days after inoculation, the average size of the mature spermogonium being 111.7 × 86.7 μ.

Aecia following spermogonia on an average of twenty-one days after inoculation on the same host organs, the lesions 0.5 to 5.0 mm. in diameter

on leaves, usually with 1 to 6 cornute peridia which become up to 2.5 mm. in length. Peridia rupturing laterally or apically, finally becoming lacerate to or nearly to the base. Peridial cells typically lanceolate-oblong in face view remaining straight or nearly so when wet, 29.4–88.2 μ in length, 11.7–36.7 μ in width, thickness of side walls 2.9–5.8 μ, inner walls 5.8–11.7 μ, outer walls 1.4–4.4 μ; the outer walls of peridial cells are smooth, the inner walls with rugose-verrucose sculpturing, and the side walls rugose with interspersed verrucose markings. Aeciospores globoid to suboval, 14.7–36.7 $\times$ 11.0–27.9 μ in size; walls 0.7–5.8 μ thick, colorless to chestnut brown, smooth to minutely verrucose and usually with 8–12, rarely with 6 or 14 pores.

Uredia lacking. Telia foliicolous and caulicolous on dense or open fasciations of branches, or caulicolous on more or less enlarged branch or stem lesions; the ungelatinized telia pulvinate, hemispheric to oval, occasionally ligulate, of a color slightly darker than chestnut brown. Teliospores one to four-celled, usually with two cells, somewhat constricted at the septa, ellipsoid to oval in shape, 19.1–60.2 $\times$ 8.8–27.9 μ; walls smooth, hyaline to dark cinnamon brown, most often pale cinnamon brown, 0.2–2.2 μ thick with one to three pores usually with an obvious papilla; pedicels hygroscopic, often enlarging just below the apices, the enlarged portion occasionally rupturing, leaving the spore with a ragged fringe or collar.

GEOGRAPHICAL DISTRIBUTION

The geographical distribution of *Gymnosporangium nidus-avis* is limited only by the ranges of its telial hosts. This is true because the pomaceous hosts, according to Rehder (1940), are present throughout northern America and extend deeply into Mexico, while the *Juniperus* hosts are more restricted; therefore the aecial hosts need not be considered as factors affecting geographical distribution. The hosts of the telial phase of *G. nidus-avis*, as is clearly illustrated in the map below, show a nearly continuous and sometimes overlapping distribution in southern Canada and the United States, except in the southwestern limits of *Juniperus virginiana* and in the southeastern limits of *J. scopulorum*. Not shown on the map and only slightly extending the geographic range is the report of Hedgcock (1940) of *G. nidus-avis* on a new telial host, *J. barbadensis* from near Gainesville, Florida. This report has been confirmed by the writer who has examined a part of the specimen and has verified the determination of the fungus name.

On the map (Fig. 1) are shown the geographical ranges of *G. nidus-avis* and its telial hosts. The small circles represent the important stations where collections of the rust were made, and where specimens from these stations have been examined and verified by the writer, while the crosses represent stations reported in the literature that have not been verified but at the same time are believed to be accurate. Whenever possible,

material was obtained to verify reports given in the literature, especially when unusual characteristics for the specimens were cited.[4] It is believed, however, that intensive collecting will show that this rust is in every state and province within the range of the telial hosts. This assumption is based on the writer's observations which have extended over an area from Maine to South Carolina and westward to southeastern Tennessee and north central Ohio where it has been found to occur locally in most districts.

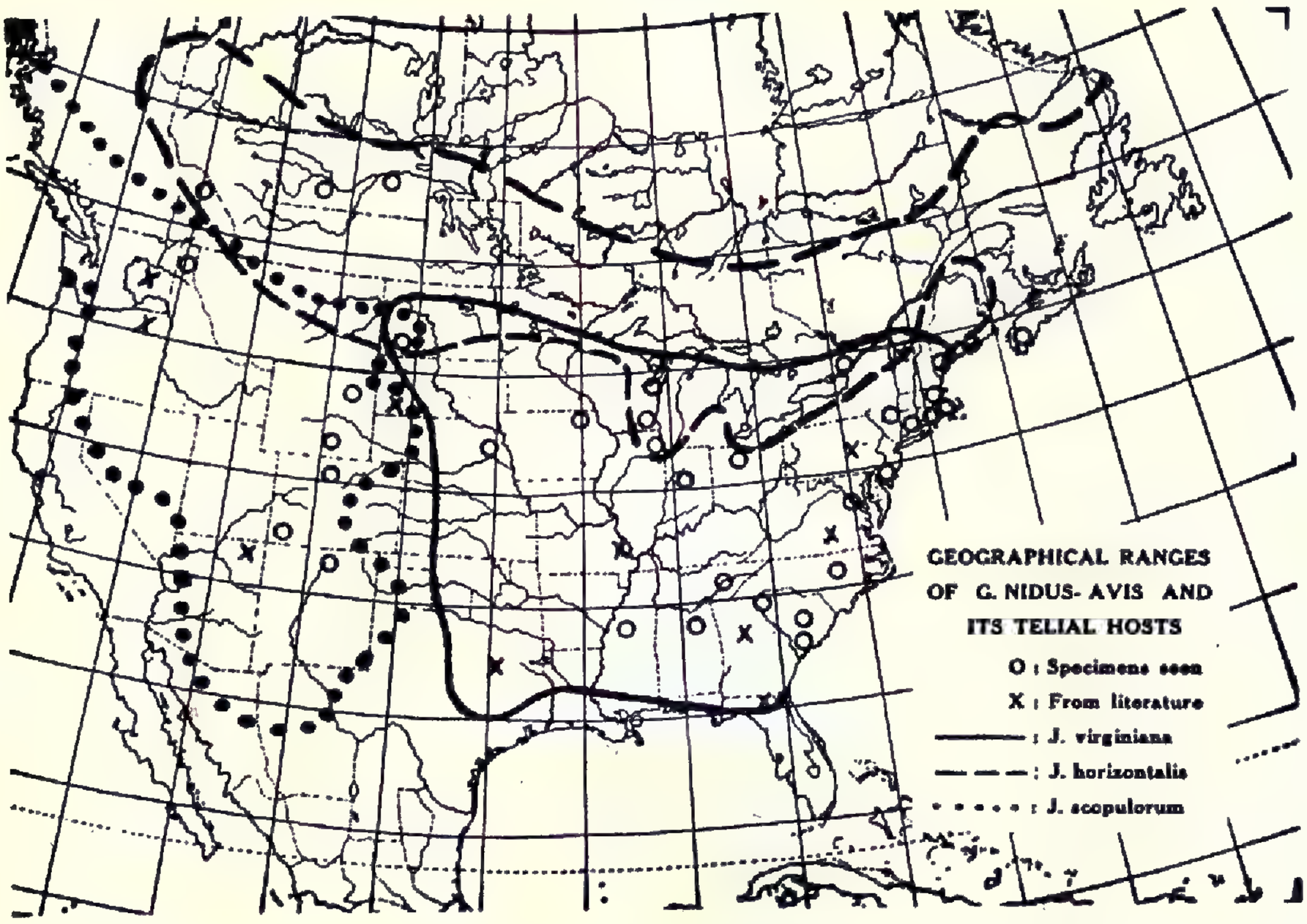


FIGURE 1. The Geographical Ranges of *G. nidus-avis* and its Telial Hosts. *Juniperus virginiana* L. including its var. *crebra* Fern. & Grisc. after Munns (1938); *J. horizontalis* Moench after Rehder (1940); *J. scopulorum* Sarg. after Sudworth (1915).

The local occurrence of this rust, in relation to its wide dispersal, is of interest and tends to confirm the reports of Kern *et al.* (1929) who stated that this fungus is rare in Pennsylvania, while Long (*in litt.*) and Coker (1920) respectively reported it as not uncommon around Washington, D. C., and Chapel Hill, North Carolina. Other reports in correspondence which have come to the writer bear out the above. Mrs. B. N. Brown was unable to find the rust in the vicinity of Marysville, Tennessee, although L. R. Hesler and the writer have observed this species in the vicinity of Knoxville, Tennessee. I. L. Conners was unable to find it around St. Catherines, Ontario; but in Saskatoon, Saskatchewan, the late Dr. W. P. Fraser indicated that it is rather common. R. W. Bailey was unable to locate the rust in the region around Ogden, Utah, while A. O. Garrett reported that it could be found several miles south of Salt Lake

[4] The report of Ray (1940) of *G. nidus-avis* from Oklahoma has been found to be based on a misdetermination and the specimen should be referred to *G. globosum* Farl.

City; J. L. Forsburg found it to be not uncommon near Fort Collins, Colorado, as did W. H. Long in the foothills of New Mexico; J. W. Hotson was unable to find the rust in the region around Seattle, Washington, while F. D. Heald indicated that this species was known only in its aecial phase around Pullman, Washington.

The reasons for the localized occurrence of this rust are not at all clear, especially when both aecial and telial hosts are in the same locality. However, from observations made during several seasons on Mt. Desert Island, Maine, it would seem that distance from the telial host limits the infection of *Amelanchier*. Evidence for this conclusion is furnished by the fact that although the different species of *Amelanchier* are common throughout the island, the only plants infected are within approximately 200 yards of *Juniperus horizontalis*, which is extremely local, being confined to the rocky ocean bluffs, and in addition is the only telial host. This is an excellent example of how the fungus may be limited to a small area, although in this instance the range is determined by the distance of the aecial host from the telial, and thus depends in part on the duration of viability in the basidiospores and in part on physiographic factors. This is in contrast to the findings of Thaxter (1891) and MacLachlan (1935b) who found that the basidiospores of other species could infect aecial hosts eight and six miles respectively from the source of inoculum. The writer's findings on Mt. Desert Island show that environmental factors may be more important in limiting the dispersal of this species.

An additional factor tending to limit local distribution is furnished by the relative period of maturation of the telial sori and the stage of development of the leaves of the aecial hosts.

Thus, in the vicinity of Clemson, South Carolina, species of *Amelanchier* are often found growing adjacent to cedars that are heavily infected with the rust. An abundance of telia was produced early in April, 1941, and gelatinization took place during four days of nearly continuous rain. At the beginning of this rainy period, several artificial inoculations were made on *Cydonia oblonga* growing in a sheltered habitat where the leaves had already begun to unfold, but at the same time the species of *Amelanchier* growing in the open had not yet started to produce leaves. On the plants artificially inoculated (*Cydonia*) the rust developed exactly the same as it did on this host at the University of Maine and in the Arnold Arboretum, yet on the species of *Amelanchier* not a single lesion was found that had resulted from natural infection. In 1942 and 1944 similar conditions reoccurred, and although artificial inoculations were successful on both *Cydonia oblonga* and *Amelanchier canadensis*, again no natural infections could be found. Here, then, is evidence that the aecial hosts must be in a condition favorable for infection, and this must coincide with the germination of the teliospores, all being more or less dependent on temperature and humidity, which confirms the conclusions of Crowell (1940).

While the examples cited above tend to explain that the viability of the spores, the physiography of an area, and the relative times of de-

velopment of foliage on the aecial hosts and telial sori may indeed play a part in the local limitation of this species, there are still other factors that have to be considered. Important among these are the effect of individual host susceptibility, and the occurrence of strains with varying degrees of virulence within this species of rust. Although there is no evidence from culture experiments that there are resistant strains of the *Juniperus* hosts, yet at any time field observations can be made which show that resistant hosts exist in quantities. As will be reported later, there is evidence resulting from culture studies that there exist resistant strains of the pomaceous or *Juniperus* hosts or both. In brief it can be stated that the species has a very wide distribution characterized by areas in which the rust is relatively scarce and in these areas the paucity of the species may be explained by one or more of the above sets of factors.

LIFE HISTORY STUDIES

SPERMOGONIAL PHASE

MACROSCOPICAL DEVELOPMENT

Heretofore very little has been published concerning the macroscopic symptoms and signs of infections caused by the spermogonial and aecial phases of *Gymnosporangium nidus-avis* on its pomaceous hosts. For recorded observations we are chiefly indebted to Thaxter (1887, 1889, 1891), Arthur (1901–1915), and Kern (1911), but for the main part these are brief and incidental to taxonomic delineations or limited life history studies of the fungus. They are also incomplete because of an insufficient number of specimens from the various hosts and geographic range of the fungus. Kern, in his monograph on *Gymnosporangium* (1911) was responsible for the enumeration of specific characters of *G. nidus-avis* and *G. juvenescens*, which at that time seemed sufficiently valid from the materials at his disposal, and which could not be checked from the life history studies then available. During the course of intensive studies of *G. nidus-avis*, the writer assembled a wide range of material from several geographical regions and carried out extensive series of culture experiments. Therefore it is possible at this time to give a more complete and connected account of the symptoms and signs of infections caused by this fungus on its pomaceous hosts than could have been done previously.

The first indication of infection, regardless of the organ affected, is a light spot or lesion in the host. These lesions soon change to a distinct yellow, then to a yellowish-orange which is more or less constant for most hosts. The lesions soon attain their definitive size and remain thereafter distinct from the adjacent uninfected host tissues, whether on leaf, stem or fruit. Subsequently, with the formation of spermogonia, the lesions lose their yellow color and become either orange-yellow or necrotic and black. Spermogonia appeared in from six to fourteen days in the writer's cultures. These organs occur singly or in a group of two to ten or more on

a single lesion. They are usually epiphyllous, occasionally hypophyllous or amphigenous on different lesions of the same leaf (Plate I, Fig. 3). In the early stages of development, the spermogonia are a waxy, orange-yellow on the lighter colored lesions. The waxy, colored appearance is caused by the colored spermatia in a viscous spermogonial fluid. The exudate is usually copious for the first five to ten days, during which time the general macroscopic symptoms normally remain unchanged, when flies and ants can be observed feeding on the exudate that has been shown by Rathay (1883) to contain sugars. As demonstrated by Craigie (1927), flies, attracted by the sweet spermogonial exudate, bring about cross-spermatization in *Puccinia Helianthi* and it seems probable that the insects mentioned above must perform the same function for this rust. It is probable also that the spermatia are transferred by water.

Following cross-spermatization, the exudate rapidly diminishes in amount and the ostiolar filaments turn a darker color. This change in color is the external indication that cross-spermatization has been completed, after which the exudate dries up entirely. During the period when spermatia are being produced, if the spermogonia are carefully examined, a definite protuberance can be seen emerging from the ostiole of each of these organs. These protuberances are made up of ostiolar filaments.

Along with the usual sequence of events in the ontogeny of the spermogonia, two distinct variations occur during the development of the infections. The degree of variation is dependent upon the host involved. Thus on *Amelanchier alnifolia* and *A. intermedia*, instead of the lesions being the usual yellowish-orange, they are reddish-orange with a yellowish-orange margin. The other important variation is the necrosis of lesions.

Necrosis as it is found in the lesions is variable and dependent upon the susceptibility of the host under attack. On the very resistant hosts, the lesions become necrotic soon after they develop. Indeed, this often takes place before the production of the spermogonia. However, occasionally some spermogonia are formed but these are small, and probably non-functional as is indicated by their failure to produce an exudate. Necrosis of the lesions occurred on the resistant and susceptible host species, like *Chaenomeles superba* and *Amelanchier stolonifera*, but on these it often may not take place until after the spermogonia and aecia are produced. When aecia are formed on these hosts some at least are non-functional, as is shown by the fact that the aeciospores produced did not germinate in tests. A very striking type of necrosis appeared on *Sorbus scopulina*, where the main part of the lesions remained alive, but a narrow zone at their periphery died.

MICROSCOPICAL DEVELOPMENT

Since the lesions and subsequent symptoms produced on the pomaceous hosts are the result of infection by the wind-carried basidiospores from the telia on the cedars, it seems desirable to follow more exactly the process

of infection and to study the subsequent development of the fungus within the host tissue.

According to MacLachlan (1935b) and other investigators, the basidiospores of *Gymnosporangium* species are carried by wind during humid spring weather. During this period the leaves of the alternate hosts are just beginning to unfold, and are often in their most susceptible condition. Therefore, when the basidiospores reach the host, germination proceeds, after a short delay, by means of germ tubes.

The germ tubes of the basidiospores may penetrate directly after germination of the basidiospores, or the germ tubes may grow to some length before they pass into the host, without the formation of appressoria, by penetrating the cuticle and becoming established intercellularly. From this it seems that the germ tubes must secrete a substance which dissolves the cuticle, thus permitting them to pass through this layer. Certainly the absence of appressoria seems to preclude the possibility of the fungus entering the host as a result of pressure exerted by the germ tubes. Infection takes place between twelve and forty-eight hours after inoculation, or perhaps even earlier under the most favorable conditions. The hyphae grow rapidly between the cells and the rust soon becomes thoroughly established in susceptible hosts. The intercellular hyphae vary considerably, but are usually 1.5–4.5 μ in diameter; they may often entirely fill the intercellular spaces and frequently appear to isolate an individual host cell from those adjacent. This fungus becomes intracellular only when haustoria are formed. In any stage of development after the fungus has become established, haustoria can be found in nearly all of the host cells in the lesion, large cells often having two or more haustoria which vary in shape from clavate, slightly curved to spiral.

Following the establishment of the fungus within a leaf, the spermogonial initials appear as knots of hyphae between the upper epidermis and the palisade layer or between the lower epidermis and spongy parenchyma cells. In this stage of development, two to six days after inoculation, the rust hyphae were seen to extend between the cells to a distance of a half-millimeter from the hyphal plexus. During subsequent development some of the hyphae in the center of the spermogonial initials elongate and appear to act as buffer cells which force the inner cell walls of the epidermis against the outer, and as a result of this pressure, the epidermis is forced outward. The buffer cells are soon replaced, however, by other fungal elements that arise from the young spermogonium. The writer's investigations indicate that the buffer cells play no part in the actual rupturing of the epidermis. This is accomplished by the continued growth of the spermogonium, while buffer cells seem to break down to make room for other developing spermogonial structures. The organ soon becomes differentiated into the spermogonial wall, from the bottom of which arise the spermatiophores and receptive hyphae, while at the same time the periphyses develop from the side wall. The spermatiophores are specialized, short hyphae, their function being to produce at their distal ends spermatia which are yellowish-orange,

ellipsoidal, and vary from 5.8–8.8 x 0.7–2.9 μ. The periphyses are hyaline, septate, subulate structures which vary in length from 58.8–133.8 μ. In addition to the periphyses are the receptive hyphae, but the latter structures arise from deep in the bases of the spermogonia instead of from the sides. The receptive hyphae are yellowish, uniform in diameter, non-septate, and have rounded apices (Plate I, Fig. 5) to which, as the writer has observed, spermatia fuse, but there was no evidence of the sub-cuticular receptive hyphae described by Allen (1930, 1932).

By the time the spermogonium ruptures the epidermis of the host, spermatia have already been produced in the spermogonial cavity. Spermatia may be liberated as early as six days after inoculation although the usual period is about twelve days, by which time the spermogonia are subepidermal and flask-shaped (Plate I, Fig. 3). After cross-spermatization has been completed, the spermogonial cavity becomes filled with elongated spermatiophores and dried up spermatial exudate, histological evidence that these organs have fulfilled their function.

The spermogonia have been used with success by Hunter (1936) as an aid in determining the various species or genera of the *Melampsoraceae*. With this in mind, it seemed desirable to make a comprehensive study of the spermogonia of *G. nidus-avis* and of *G. juvenescens* since the latter species has been accepted up to the present time. As is shown by measurements of one hundred medial sections, these organs vary in size from 80.8–171.9 μ high by 64.7–132.3 μ in diameter, the average size being 111.7 x 86.7 μ. The above one hundred measurements included fifty each of *G. nidus-avis* and *G. juvenescens*. The average dimensions of the *G. nidus-avis* spermogonia were 111.5 x 84.8 μ while those of the *G. juvenescens* were 111.5 x 88.9 μ. The evidence thus furnished by the nearly identical size and morphology of the periphyses, spermatia, and the size of the spermogonia, since these structures are relatively large, may accordingly be considered as showing only minute variations. Furthermore, the time of appearance of the spermogonia is the same in both species, and for this and the preceding reasons, *G. juvenescens* is considered to be the same as *G. nidus-avis*.

Earlier in this chapter I have described the external symptom of necrosis of some lesions. The histological symptomatology of the necrotic lesions was studied in detail. This was undertaken because it became necessary to determine whether or not necrotic lesions appearing on very resistant hosts were caused by *G. nidus-avis* or some other fungus. Even preliminary examinations showed that necrotic lesions caused by the rust fungus had what I have chosen to call an invasion zone (Plate I, Fig. 4). The invasion zone, showing the reaction of the host against the rust, is characterized by having a layer of host cells which are filled with a resin-like material that is yellowish in unstained sections, but in stained preparations takes dyes readily and stains deeply. The resin-like material appears the same in all respects as that to be found in the leaf spots where it is scattered throughout the infected area, whereas in the invasion zone of the necrotic lesions it is concentrated. Within the infected area of the leaf tissue the host cells may be

entirely dead while those of the healthy leaf tissues outside of the invasion zone are alive and have the usual arrangement of chloroplasts. Without exception, when the invasion zone was evident around necrotic lesions, rust hyphae could be found, but when the invasion zone was lacking, typical rust hyphae could not be found. Therefore, necrotic lesions on hosts that lacked invasion zones were considered to be caused by agents other than *G. nidus-avis*. Correlated with this is the fact that when there were necrotic lesions without there being an invasion zone on inoculated leaves, similar lesions also occurred on uninoculated leaves. Thus by using the presence of the invasion zone as a criterion for the presence of *G. nidus-avis*, it was possible to exclude necrotic spots caused by other fungi.

As others have previously suggested, plants are able in some degree to inhibit or prevent the growth of fungi. The presence of this invasion zone in the resistant plants would, then, appear to be a reaction by the host to prevent or limit the spread of the fungus since no hyphae were found beyond this barrier, whereas in susceptible host species in which no invasion zone is formed, the fungus hyphae can be seen well beyond the limits of the lesion.

AECIAL PHASE

MACROSCOPICAL DEVELOPMENT

The aecial phase starts at about the time the spermogonia are completing their function and becomes evident as a result of more or less hypertrophy accompanied by a change in the color of the affected host parts. The color of that part of the lesion from which aecia finally emerge is nearly always yellow, but frequently when the spermogonia are epiphyllous, the under side of the leaf does not turn yellow until the formation of the aecial fundament which is usually accompanied by hypertrophy. The amount of hypertrophy varies in degree and occurrence according to the relative susceptibility of the host, and according to the organ involved. In the more or less circular leaf lesions, no enlargement of the host tissue takes place until the aecia begin to form, at which time there is a slight swelling of the lesion from which a single aecium or several aecia finally emerge. The swelling is absent on resistant hosts where there is no indication of aecia even though spermogonia are present. Some hypertrophy is evident, however, if aecia do develop on resistant hosts; it is smaller when the aecia remain embedded, and larger when they emerge.

There are two general types of leaf lesions, their shape depending on their relative position with respect to the major veins. Most of the lesions occur in the thin parts of the lamina where there are no major veins and the size is influenced by the susceptibility of the host, it being smaller on the more resistant species and larger on the more susceptible. On *Amelanchier stolonifera*, a susceptible species, the spots vary from 0.5–2 mm. but on *Amelosorbus Jackii* (Plate I, Fig. 1), a very susceptible species, their diameters vary from 2–5 mm. When lesions occur on leaf veins, there is always some

hypertrophy, with the vein as its long axis. These swellings are usually hypophyllous, but may be evident on the upper leaf surface. A severe vein infection often causes a distortion of the leaf (Plate I, Fig. 2), and in addition the aecia may be amphigenous. Likewise, on affected fruits, the amount of hypertrophy is not readily assessed. Infected fruits are not much larger than the uninfected, but they are more or less distorted. When young stems become infected, there is also more or less distortion and a conspicuous enlargement (Plate I, Fig. 2). No comparison has been made in this discussion of the macroscopic symptoms of *G. nidus-avis* and *G. juvenescens*, because there were no variations in the developmental stages of the two species that could be distinguished.

MICROSCOPICAL DEVELOPMENT

The nuclear phenomena which occur during the transition from the spermogonial phase to that of the aecial phase have not been entirely worked out for any rust. Unfortunately the writer has not been able to contribute to the elucidation of this phenomenon, but it is postulated that cross-spermatization is followed by dicaryotization. This latter process may begin when the haploid nucleus of the spermatium has passed into the receptive hypha, and end when the haploid aecial fundament becomes dicaryotic. It is then that the aecial phase is initiated. This stage marks the beginning of a period of rapid development of the aecia which is correlated with a reaction of the host that is almost immediate. The apparent host reaction is to increase the size and number of the cells of the lesion. In this stage of development, hyphae are discernable considerably beyond the limits of the infection zone where there is no visible host reaction.

Aecial primordia, each consisting of a plexus of haploid hyphae, appear about the time the spermogonia are mature, are formed just below the palisade cells in the leaves. Aecial primordia appear about six days after cross-spermatization has been completed or about twenty-four days after inoculation.

The formation of the hyphal plexus is accompanied by a breaking down of host cells in the area, followed by the development of large thin-walled cells approximately at the center of the primordium. The aecial hymenium soon becomes visible in the lysigenous cavity formed by the dissolution of the thin-walled interwoven hyphae. The peripheral and apical cells appear as the initial peridial cells (Plate I, Fig. 6). The elongating peridium appears not to force its way out of the hypertrophied host tissue but to follow a path of rust hyphae which in turn seem to break down the host cells in advance of the apex. No evidence was found that would indicate that the host cells were forced to one side by the apex of the peridium or that the epidermis was actually split to allow the peridium an exit.

By the time the aecium reaches the surface of the host, the apical portion is filled with a mass of loose spores. Only those in the process of formation remain attached to the clavate sporophores. The peridium and the enclosed structures are all dicaryotic, whereas the hyphal plexus, which

surrounds the peridial envelope, is for the most part haploid. Since it is formed before dicaryotization, this hyphal plexus is considered to be of a more or less stromatic nature not properly belonging to the aecium. However, among the haploid cells there are some scattered hyphae which secondarily have become dicaryotic.

A careful study was made of the development and morphology of the peridial cells and aeciospores because these structures were supposed to show differences which enabled Kern (1911) and Arthur (1934) to distinguish between *G. nidus-avis* and *G. juvenescens*. The differences were to be found in the method of peridial dehiscence, in peridial cell morphology and aeciospore size.

My own observations show that the peridia, regardless of the origin of inoculum used for the cultures, may rupture apically soon after emergence, or retain their cornute form until after elongation has been completed. This phenomenon appears to depend upon whether or not they are alternately wetted and dried or whether dehiscence is retarded during a dry season. Cultures made with western material of *G. juvenescens* in Maine during 1938 developed exactly in the same manner as did the indigenous rust, *G. nidus-avis*. The peridia dehisced apically soon after their emergence and became lacerate to, or nearly to, the base. The same method of dehiscence occurred with the cultures that matured the latter part of June and early July 1939, in the Arnold Arboretum. However, cultures, regardless of the origin of the inoculum, that matured later during almost drought conditions, did not dehisce at all or only after collection. When the cornute form is retained by the peridia, rupturing first occurs laterally, followed by the rupture of the apex, after which the peridium becomes lacerate, its parts usually remaining straight or only slightly divergent. In some cases only the apex ruptures and the peridium retains its cylindric form. It was found that such peridia were made up of cells with finer markings than those peridia which become more lacerate. These findings do not agree with those of Kern (1911) and Arthur (1934) who reported that in *G. nidus-avis* the peridium ruptures apically and becomes lacerate to the base, while in *G. juvenescens* the peridium is tardily dehiscent at the apex, the rupturing first occurring laterally, and finally the peridium becomes lacerate nearly to the base. Because of the reported variation in the method of peridial dehiscence, an attempt was made to explain this by a careful study of the morphology of the cells of the peridium.

Kern (1911) described the peridial cells of *G. juvenescens* as "lanceolate-oblong in face view, 16–23 x 65–110 μ, linear-rhomboid in side view, 17–27 μ thick, outer wall rather thin, 1–1.5 μ, smooth, inner and side walls medium thick, 5–7 μ, finely and closely verrucose-rugose with irregular and oftentimes ridge-like papillae." Arthur (1934) added that the cells remain straight when wet. Kern (1911) described the peridial cells of *G. nidus-avis* as "lanceolate in face view, 15–23 x 55–88 μ, linear in side view, 14–18 μ thick, outer wall 1–1.5 μ thick, smooth, inner and side walls 5–7 μ thick, coarsely rugose with narrow ridges, with shorter often roundish papil-

lae interspersed." Arthur (1934) again added the important character that these cells remain straight when wet.

Fischer (1891 and 1895) and Kern (1910) pointed out that peridial cell markings were very important in differentiating between species of *Gymnosporangium*. I have made extensive observations on many different species of this genus and have likewise found this character to be the most dependable for taxonomic delineations.

The apparent differences between the peridial cells of *G. nidus-avis* and *G. juvenescens* as stated above are in the length, thickness, and wall markings. Accordingly, an attempt was made to confirm the constancy of these characters. Samples of peridial cells from cultured material were measured. The inoculum used to produce the aecial specimens originated from Saskatchewan, Colorado, Tennessee, Maine, Massachusetts, North and South Carolina. The dimensions measured were length, width, thickness and thickness of the side, the inner and the outer walls. Extreme variation was encountered in the lengths and widths of the peridial cells from all of the regions listed. Only cells from the side walls of the peridia with typical oblong-lanceolate shape were measured. The results of these measurements are recorded (Table 1) according to the *Juniperus* host from which the inoculum originated to produce the fungus.

TABLE 1. DATA ON PERIDIAL CELL DIMENSIONS OF *G. nidus-avis* TABULATED ACCORDING TO THE ORIGIN OF THE INOCULUM USED TO OBTAIN THE AECIA

Origin of Inoculum	Length μ	Width μ	Thickness μ	Wall Thickness Side μ	Wall Thickness Inner μ	Wall Thickness Outer μ
J. horizontalis Sask.	29.4–88.2	11.7–25.0	14.7–36.7	2.9–5.8	5.8–8.8	1.4–4.4
J. horizontalis Maine	29.4–88.2	11.7–25.0	11.7–36.7	2.9–5.8	5.8–11.7	1.4–4.4
J. scopulorum Col.	35.2–88.2	11.7–22.0	11.7–30.2	2.9–5.8	7.3–10.2	1.4–4.4
J. virginiana Mass.	36.7–88.2	14.7–23.5	11.7–33.8	2.9–5.8	7.3–11.7	1.4–4.4

No significant differences are evident that would separate the eastern from the western rusts. Fischer (1891) and Arthur (1934) used only the outer and inner wall measurements; therefore additional measurements were made using only those dimensions. This time cultures were obtained from inoculum from Maine and Saskatchewan on *Juniperus horizontalis*, Colorado on *J. scopulorum*, and Maine and Massachusetts on *J. virginiana* (Table 2).

TABLE 2. DATA ON OUTER AND INNER PERIDIAL CELL WALL MEASUREMENTS TABULATED ACCORDING TO THE ORIGIN OF THE INOCULUM USED TO OBTAIN THE AECIA

Origin of Inoculum	Wall Thickness Outer μ	Wall Thickness Avg. μ	Wall Thickness Inner μ	Wall Thickness Avg. μ
J. horizontalis Maine	4.4–14.7	8.5	0.7–4.4	2.5
J. horizontalis Sask.	5.8–14.7	8.9	0.7–4.4	2.6
J. scopulorum Colo.	5.8–14.7	9.2	0.7–4.4	2.7
J. virginiana Maine	4.4–14.7	8.5	0.7–4.4	2.5
J. virginiana Mass.	4.4–14.7	8.4	0.7–4.4	2.7

Measurements of the thickness of the walls also confirm the data in Table 1, and hence these results offer further substantiation of the thesis that *G. nidus-avis* and *G. juvenescens* should not be distinguished.

Since the above biometrical studies show no reason for the separation of the two species, the investigations were carried further by careful comparisons of the sculpturing on the peridial cells. The usual markings observed on peridial cells regardless of the origin of the inoculum has been found to be rugose-verrucose. The side walls are rugose with some verrucose markings interspersed. The inner walls are rugose along the sides, these rugae being extensions from those on the side walls. The centers of the inner walls are usually covered with short ridge-like papillae and verrucose markings. The outer walls are smooth. The more resistant hosts tended to produce aecia with more verrucose-rugose peridial cells than were found on susceptible species. However, this was not constant enough to indicate an expression of the effect of the host reaction on the morphology of the fungus.

Just as the preceding peridial characters were studied, so have those furnished by the aeciospores. Since the aecia of both *G. nidus-avis* and *G. juvenescens* could be produced by inoculation on similar hosts, further attempts were made to distinguish the species by their spore characters. Therefore measurements were made of the spore dimensions and the thickness of the walls, while at the same time counts were made of the number of pores, and notations were made of spore wall color and markings.

No differences could be found in the color of the walls. The variation, regardless of the origin of inoculum ranged from hyaline through cinnamon to chestnut brown or even darker, although some peridia were found to contain nearly all hyaline spores. The number of pores were counted only when they could be seen distinctly and it was found that the usual number of pores per spore varied from eight to twelve, although very rarely spores with six or fourteen pores were found.

Similarly, other characters to be found in the aeciospores regardless of the origin of the inoculum show no significant differences which would warrant separating the two species. Thus the shapes of the spores range usually from globoid to suboval although in any sorus it is possible to find abnormal spores which are easily distinguished from those characterized as normal. Just as the normal shape of the spores varies within relatively narrow limits, so do the surface characters of the aeciospore walls. A large series of observations on this point leads the author to conclude that the spores may vary from smooth to minutely verrucose. Not only is there this variation in the spores from the same aecium, but even using the same spores, the appearance of the markings may vary with the mounting medium used, — in lactophenol the markings stand out when present whereas when the spores are mounted in water, the minutely verrucose spores may appear smooth. Although the presence or absence of markings on the walls of the aeciospores has served various authors for separating *G. nidus-avis* from *G. juvenescens*, the present observations demonstrate that such dif-

ferences are not significant. The thickness of the aeciospore walls is relatively constant regardless of the origin of inoculum used to produce the spores. On the basis of 408 measurements of both eastern material of *G. nidus-avis* and of spores cultured from Colorado and Saskatchewan inocula, it was found that the thickness of the walls of the former varied between 0.7 and 6.5 μ but with a mean of 2.99 μ, whereas walls of the aeciospores which were produced from western inoculum varied from 1.0–5.8 μ with a mean thickness of 2.7 μ, or a difference of only 0.29 μ between the averages. This difference is so small that it is not considered to be of any taxonomic value for the separation of the eastern rust from the western.

Since other characters of the aeciospores have proved of little value in separating the two species, a careful determination was made of the aeciospore dimensions. It was believed that these, if anything, might enable one to distinguish the two species in question by following the examples set by Levine (1923) who was able to distinguish physiological races of a rust, and Colley (1925) who separated two closely related species by the use of biometry. For these biometrical studies, notes and data were kept separate for all the kinds of inocula used throughout the cultural investigations. The data in Table 3 are based on aeciospores produced from eastern inoculum collected on *J. virginiana* var. *crebra* in Massachusetts, *J. virginiana* from North Carolina, South Carolina, and Tennessee, while the western inoculum was from *J. scopulorum* growing in Colorado and *J. horizontalis* growing in Maine and Saskatchewan. Since the inoculum from all sources was used on the same pomaceous hosts to obtain the aecia, it is believed that any differences between the eastern and western inocula would become evident. In Table 3 not only is there a comparison of the dimensions of aeciospores produced by the eastern and western inocula, but also differences within each of these series.

TABLE 3. AECIOSPORE SIZE IN RELATION TO THE GEOGRAPHICAL ORIGIN OF INOCULUM USED FOR AECIAL CULTURES

Origin of Inoculum	No. of Spores	Range of Lengths μ	Mean Lengths μ	Range of Widths μ	Mean Widths μ
East	500	17.0–32.0	23.4	14.0–26.0	20.3
West	500	17.0–33.0	22.9	11.0–26.0	19.6
Mass.	400	16.1–30.8	22.6	13.2–23.5	17.7
Maine	400	17.6–33.8	22.1	14.7–25.0	19.6
Sask.	400	14.7–35.2	23.5	11.7–27.9	19.3
Colo.	400	14.7–36.7	22.0	13.2–25.0	18.4
Average		14.7–36.7	22.7	11.0–27.9	19.1

In this comparison it can be seen that the ranges in the lengths and widths of the two sets of spore measurements are very similar, but what is more important is that the differences in mean spore lengths and widths are insignificantly small, the differences in the mean lengths being only 0.5 μ, while in the mean widths the variation between spores produced from the eastern and western inocula is only 0.7 μ. An analysis of the data in Table

3 shows that the greatest difference in the average spore lengths is between the spores produced from the Colorado and Saskatchewan inocula, the difference being only 1.5 μ. In the mean spore widths the greatest difference of 1.9 μ is between the aeciospores cultured from the Maine and Massachusetts inocula. In consideration of the large size of the spores, the variations seem of little consequence, especially since in a comparison of the aeciospores from the eastern inocula with those from the Maine and Massachusetts inocula, the difference between the mean lengths was equally as small, 0.5 μ, while in the spore widths the difference is 1.9 μ compared to 0.7 μ. Similar differences exist between the spores produced from the Saskatchewan and Colorado inocula. It is now possible to conclude that the aeciospore dimensions have no character which might permit the separation of *G. juvenescens* from *G. nidus-avis*. However, the minute tendencies toward variation do indicate the beginnings of biological specialization which becomes very evident when host susceptibility is taken into consideration, a subject which will be discussed in a following section. Here again is emphasized the very close similarity of the eastern and western rusts. Thus it is shown here as in the preceding paragraphs of this section that there are no differences either in the spermogonial or in the aecial phases which might be considered large enough to delimit *G. juvenescens* from *G. nidus-avis*. The careful comparison of the western and eastern rusts was carried to the telial phase which is to be considered in the section to follow.

THE TELIAL PHASE

MACROSCOPICAL DEVELOPMENT

Gymnosporangium nidus-avis has been confusing as a species not only in its aecial phase but also in its perfect or telial stage because of the variability in its manifestations on various species of *Juniperus*. The extreme in variation is shown in a statement by Arthur (1910) when he described a collection of stem inhabiting telia from South Carolina as having an appearance like a large *Tremella* and which was not accepted as a rust until it was examined microscopically. As the result of extensive investigations and observations, the writer has been able to coordinate the sometimes very diverse points of view and to extend the knowledge of the telial phase of *G. nidus-avis*. Observations have been made from Maine to South Carolina and west to Tennessee and Ohio and in addition numerous herbarium specimens from the entire range (Fig. 1) of the rust have been carefully examined.

The most characteristic symptom caused by the fungus *G. nidus-avis* is the production of a fasciation of branches which when seen from a distance resemble a bird's nest. These fasciations, being more commonly known as brooms, appear to have their origin when a terminal or lateral growing shoot becomes infected.

In this respect there are three expressions of fungus infection: the

first a very dense broom with the subulate or juvenile form of leaves (Plate II, Fig. 1), that may reach twenty-four inches or more in diameter, and become fifteen or more years old. Many of the branchlets, arising from about the same place on the main branch or stem, remain slender throughout the life of the broom and retain most of their acicular leaves. The second form of broom is similar to the first except that the foliage remains normal. They do not appear as compact because the leaves remain closely appressed to the branches (Plate II, Fig. 2). Just why some brooms have subulate and others scale-shaped leaves is not clear, but both forms of brooms have been seen on the same tree and rarely a broom with acicular leaves may be found with one branch retaining its normal foliage. The third symptom of infection is different in general aspect from the first two, it being characterized by the fewer, more widely separated branchlets which retain their scale-shaped or sometimes subulate leaves only at their extremities. The branchlets become somewhat enlarged in diameter and very rough. The first symptom of infection occurs commonly on *Juniperus horizontalis*, *J. scopulorum* (Plate II, Fig. 4), *J. virginiana* var. *crebra* [5] (Plate II, Fig. 1) and occasionally on *J. virginiana*; the second on all of these hosts, while the third type is the common one on *J. virginiana*, although sometimes it occurs on *J. virginiana* var. *crebra*.

The fungus does not confine itself to the brooms but often invades the supporting branch or stem and the mycelium may extend several feet away from a broom. In addition, branches (Plate II, Fig. 3) and old stems not associated with brooms may be infected. When branches and stems are attacked by *G. nidus-avis*, the effect on the morphology of the host may or may not be externally apparent. Small young branches and stems may be slightly enlarged in diameter, the bark is usually very rough with deep longitudinal and transverse fissures, or occasionally, as Dodge (1918b) has reported, the bark may actually be split open. Sometimes, however, young infected branches do not show enlargement, and the only external evidence of the fungus is the presence of telial masses or the oval scars left in the outer bark just after the telia fall. When infected stems and branches become older, there is considerable enlargement, and the deeply furrowed bark of the infected area may be seen. Hartley (1913) reported an exceptionally large trunk lesion six feet eight inches long, and another lesion where the fungus had continued to spread for thirty-two years after the bark in the center had died. Similar symptoms are not uncommon on old trees that have been infected for many years.

As there is a difference in the characters of brooms produced on the telial host, there is also a difference in the occurrence of telia on branches and stems. From observations and specimens examined, it has been found that on *Juniperus virginiana* the telia usually occur on leafless parts of branches and stems and this is apparently also true on *J. barbadensis*,

[5] The variety of *Juniperus virginiana* can be distinguished from the true species with characters described by Fernald and Griscom (1935).

since the only collection of *G. nidus-avis* on this host that has been made was on a branch. On *J. virginiana* var. *crebra* and *J. horizontalis* the telia occur on both leafy branchlets and the older leafless branches and stems, while on *J. scopulorum* no telia have been seen that were not associated with a broom. This latter was at first thought to be a coincidence, but a careful examination of all available specimens, both fresh and dried, failed to give any evidence that telia were formed away from the brooms, and, therefore, it was concluded that such telia do not occur, or if they do, only rarely. Long (*in litt.*) has confirmed this conclusion from his observations of this rust on *J. scopulorum*.

MICROSCOPICAL DEVELOPMENT

The external alterations in the host morphology are not usually a true indication of the extent to which the rust has spread through a given host. For this reason it is necessary to examine sections of the host microscopically to determine whether or not rust hyphae are present. Such investigations show that the mycelium is present throughout the host tissues of the dense brooms and the large, yellowish-orange hyphae can be found through the tissues of the bark where, in stems one to five years old, the intercellular spaces of the cortex are much larger than in uninfected stems, thus making this region somewhat thicker than normal. These intercellular spaces are often crowded with rust hyphae which are also in the phloem, and cambial region, and not uncommonly extend into the xylem along the medullary rays, by which they may reach the pith, and in addition hyphae can be seen occasionally in the tracheids. Hyphae often can be found also in the subulate leaves of brooms, but even when brooms have a normal foliage, the leaves are frequently invaded by the fungus. The mycelium may also extend several inches away from the broom into the supporting branch or in advance of a branch or stem lesion without causing external symptoms. During the invasion of the host, the fungus mycelium spreads more rapidly longitudinally along the main axis of the branch or stem than transversely. The rate of spread longitudinally, as shown by Dodge (1931) is at least six inches in three years.

The effect of the fungus on its telial hosts having been considered, a treatment of vegetative and reproductive stages of the rust, *G. nidus-avis*, in its telial hosts will be discussed in the paragraphs to follow.

The mycelium is yellowish-orange and very irregular in size but usually 3–5 μ in diameter, penetrating and branching between the host cells, sending the small clavate haustoria into the parenchyma cells of the host. The hyphae can be seen also in the intercellular spaces of the cortex on young stems and the spongy parenchyma of the leaves. At any time of year, but most commonly late in the fall, large knots of hyphae are produced which represent the earliest beginnings of the telial primordia. Their presence may be indicated externally by a slight discoloration, but usually they are invisible to the unaided eye. There seems to be a slight amount of growth in the hyphal knots which may well occur in brief warm periods during

the winter. In early spring, definite telial primordia can be seen under the phellogen of the stems and the epidermis of the leaves, and these rapidly mature during the moist warm weather so that the telia are fully developed at about the time the leaves of the alternate hosts are being formed, the exact time of year varying considerably within the geographic range of the fungus — by early March in Florida, but not until May or early June in Maine. It is especially interesting to note that in both Fort Collins, Colorado, and Saskatoon, Saskatchewan, these sori are completely developed in early May. The telia appear from the nodes, internodes and leaves on the dense brooms, regardless of host or whether the foliage is of the scale-like (Plate II, Fig. 2) or acicular form. On the open stag-horn brooms, however, they are mostly on the older leafless parts of the branchlets where the telia occur irregularly (Plate II, Fig. 3). This is also true as to occurrence and position of the sori on the leafless parts of branchlets in the dense brooms, and on branches and stems not connected with a fasciated portion of the host. On young branches with smooth bark, the telia emerge at the margins of telial scars of previous seasons or cause new lesions, while on older branches and stems, the telia emerge from between the fissures of the rough bark.

In reference to the characters of the telial sori, shape, size, and color are of significance taxonomically. The first two are the most constant, but while shape should be considered both before and after gelatinization, size and color are of importance only before this takes place. The telia, when in the fresh ungelatinized condition and when they occur on the leafy, fasciated or normal branchlets, are pulvinate, hemispheric or oval, or occasionally tend to be ligulate, but these sori always have smooth surfaces. Only rarely are the telia confluent on leafy shoots, but are commonly seen in this condition on leafless parts of branches and stems. The telia inhabiting these leafless bark surfaces are about the same in shape as those on the brooms but tend to be larger and often coalesce, giving rise to a narrow elliptical sorus. Ligulate telia are not uncommon on stems, but in this instance they are never furcate, rough surfaced, or lacunose, this combination of characters being descriptive of the telia belonging to *G. effusum* and not *G. nidus-avis*. The dimensions of the ungelatinized telia are 1–6.5 mm. in diameter and 0.5–5.5 mm. in height on brooms, while on leafless, scaly-barked branches and stems they are 3–5 mm. long, 3–6 mm. wide and 2–9 mm. high. Upon gelatinization, the telia enlarge considerably in height, but little in diameter and width or in length along the stem. The highest gelatinized telium measured was 16 mm. In this condition they are globoid, ellipsoid or sometimes ligulate. Dodge (1931) reported a telium at least two inches in length which is longer than any the writer has seen.

In addition to a study of the size and shape of the telial sori, their usual color was determined by comparison with standard color charts in Maerz and Paul (1930). Color is probably the most variable of the telial characters, but in the fresh condition just after emergence, it has been found to

be reasonably constant, regardless of the host or position on the host. It should be mentioned here that no telia appeared to be exactly chestnut or cinnamon brown in the ungelatinized condition as reported by Kern (1911) and Arthur (1934). By careful and repeated comparisons, the color of ungelatinized telia on *J. virginiana* were found to be "Coromandel," on *J. scopulorum*, "Cordova," and on *J. horizontalis*, "rustic brown." All three of these colors are slightly darker than chestnut. Fully gelatinized telia were determined to vary from a light yellowish-orange to a darker yellowish-orange or "Spa Tan." Telia repeatedly gelatinized become cinnamon-brownish. After one long period of gelatinization, such as during a continued rain or after three or four brief periods of extension, the telia drop from their host leaving oval scars which are at first yellowish-orange from the remaining mycelium. Sooner or later, however, the scars become covered by callous tissue formed by the host. Regardless of the host, while the telia are still attached or immediately after they fall off, the colored subtending tissue mentioned above is nearly always present. Telia that emerge from the fissures of old bark often drop off or dry up after gelatinization without leaving evidence of their presence.

Although the telia may be somewhat affected by changes in the substratum or by ecological conditions, the teliospores are little affected by these factors, and therefore offer many important taxonomic characters. Because of this, a study has been made of the spore development and morphology, and a separate investigation on the process of germination which includes basidium and basidiospore formation and the discharge of the latter (Prince, 1943). Fully formed teliospores can be found before the host tissue, which covers the telium, has been ruptured, but if specimens are collected early enough in the spring it can be seen that prior to the formation of the teliospores there are telial primordia, the ontogeny of which has been carefully described and illustrated by Dodge (1918a), who pointed out that the terminal cells of the primordia elongate three to five times their diameter and form buffer cells which are followed by teliospores that arise from penultimate cells. Upon the enlargement of the teliospores and elongation of the pedicels, the host tissue covering the telium is finally ruptured.

The mature teliospores are very irregular in shape, size, and number of cells. Their shape varies from ellipsoid, tapering at both ends, through oblong to oval with both ends more or less obtuse. The most common form of teliospore is ellipsoid with both the upper and lower cells tapering slightly, and almost without exception they are somewhat constricted at the septum or septa which when present divides the spore into two or more cells. The number of cells in each spore varies from one to four. Mesospores, characterized by being one-celled, are commonly seen among the spores of the telium while the three and four-celled teliospores are rarely seen. The smooth teliospore walls are usually pale cinnamon-brown but the walls of some spores may be hyaline while others are dark cinnamon-brown. Similarly, the thickness of the wall is variable also, ranging

from 0.4–2.2 μ. The walls of the two-celled teliospores have pores that are nearly always papilliate. The pores are located at the septa, except for the frequent presence of an additional apical pore in the upper cells. There are no basal pores in the lower cells. In spores with three or four cells, the pores are located as in the two-celled spores, while the pores are apical in mesospores.

At an early stage the pedicels become differentiated from the teliospores which eventually become septate and enlarge in diameter while the stipes for a long time retain their original diameter, but elongate. During the final stages of elongation, the wall of the pedicel becomes thickened and by the time the spore has matured it has become somewhat hygroscopic. The top of the pedicels just below the spores often enlarge in diameter but never become bulbous like those of *G. clavipes*. When the top of the pedicels do enlarge upon gelatinization, this may continue to the extent that the outer wall bursts leaving a ragged fringe attached to the base of the spore, but with the inner wall surrounding the lumen remaining intact and continuous with the lower portion of the pedicel which does not break away or deliquesce.

As is true with the characters of the aeciospores, those of the teliospores do not furnish evidence that would lead one to consider *G. juvenescens* to be distinct from *G. nidus-avis*, nor are there any valid differences that would separate the eastern from the western strains. The only character that might be considered valid is that on *J. scopulorum* the telia do not occur on the old branches and stems away from the brooms, whereas on *J. virginiana* the telia are produced on these parts of the hosts. This difference, however, cannot be accepted because on *J. horizontalis* the telia occur on both the leafy shoots of brooms and on branches not connected with brooms. In addition to these facts, the morphology and size of the telia are the same regardless of host, and therefore from investigations by the writer, *G. juvenescens* is not a valid species.

In a letter dated July 18, 1941, Dr. Long agrees with the author that *G. juvenescens* on *J. scopulorum* is the same as *G. nidus-avis*, but he writes that he has seen *G. juvenescens* causing brooms with normal needles as well as the acicular form "but in all cases the brooms were dense and not of the open type that is found in certain areas of the east." Dr. Long believes that the open type broom which occurs more commonly in the South on *Juniperus virginiana* may be caused by a different rust than that which causes the dense brooms that are more common on the northern cedars (*Juniperus virginiana* var. *crebra*). His basis for this belief is that he examined 3040 "eastern red cedar" trees in and near the District of Columbia. Of the trees examined, 382 were infected with *G. nidus-avis*. Data recorded according to the type of symptom produced showed that on the infected trees there were 58 trunk lesions, 1108 branch lesions, 484 brooms of the open type, and 1 "poor little broom" with acicular leaves on a stunted tree. During additional observations in Arkansas he found that the cedars there also had only the open type of brooms. Additional char-

acters, he believes, that distinguish the southern from the northern rust, are that his observations show that the bark under the telia is a golden yellow during the development and gelatinization periods of the telia and that there are many mesospores in southern telia. He seems to have compared his extensive observations of southern specimens with a single collection from Sharon, Massachusetts, and because the latter specimen lacked certain characters present in the others he believes they are different.

These differences are invalidated, first because he did not recognize the two kinds of eastern red cedars, *J. virginiana* and *J. virginiana* var. *crebra*, the former of which, as has already been pointed out in this work, usually forms open brooms when attacked by *G. nidus-avis*, while the latter usually has dense brooms under the same conditions. In addition, the true *J. virginiana* according to Fernald and Griscom (1935) may occur as far north as eastern Massachusetts, but is most abundant from the coastal plain of New Jersey south and westward. Thus the cedars in Washington, D. C., and Arkansas are well within the range of the true species and not the northern variety. Secondly, the orange coloration of the bark under the telia is characteristic for at least two species of *Gymnosporangium* in addition to *G. nidus-avis*. Thirdly, during the present investigations, the orange coloration under the telia has been observed on all the *Juniperus* hosts of *G. nidus-avis* studied by the writer in the field; and finally, mesospores are not uncommon in the telial sori regardless of host or locality. Therefore it seems evident that it is important not to separate *G. nidus-avis* into geographical species or varieties by the broom types, coloration of the host tissue under the telia, or by the presence of mesospores.

As a further test of the possibility that *G. juvenescens* could be distinguished from *G. nidus-avis* in the telial phase, it would be possible to do it on the basis of teliospore dimensions. Accordingly, the lengths and widths of one hundred spores were measured from each of seven geographical localities; the collections coming from the following species of *Juniperus* from the different localities:

J. horizontalis Moench.	Bar Harbor, Maine
J. horizontalis Moench.	Saskatoon, Saskatchewan
J. scopulorum Sarg.	Fort Collins, Colorado
J. virginiana L. var. *crebra* Fern. & Grisc.	Canton, Jamaica Plain, Norwood, and Waltham, Massachusetts
J. virginiana L.	Chapel Hill, North Carolina
	Clemson, South Carolina
	Montvale Springs, Tennessee

In addition, the measurements were based not on spores derived from a single telium, but from several telia on specimens collected or received while these investigations were in progress, and only spores from dried telia mounted in lactophenol were used. Thus it was possible to obtain

from each host and locality a good representation of the degree of variation in the size of the spore, the basis of the data in Table 4.

TABLE 4. THE SIZE OF TELIOSPORES OF *G. nidus-avis* FROM DIFFERENT TELIAL HOSTS AND LOCALITIES

Hosts	Spore Lengths in μ	Mean Lengths μ	Spore Widths in μ	Mean Widths μ
Juniperus				
horizontalis (Me.)	22.0–47.0	32.8	11.7–27.9	17.3
horizontalis (Sask.)	25.0–63.2	37.1	11.7–27.9	16.5
scopulorum (Colo.)	19.1–50.0	34.4	11.7–22.5	16.2
virginiana var. *crebra* (Mass.)	26.4–51.4	35.8	13.2–23.5	17.0
virginiana (N. C.)	23.5–55.8	38.3	10.2–25.0	17.4
virginiana (S. C.)	22.0–60.2	41.7	10.2–22.0	16.2
virginiana (Tenn.)	20.5–51.4	39.4	8.8–23.5	16.3
	Total Range in Spore Lengths	Mean Length	Total Range in Spore Widths	Mean Width
	19.1–60.2	37.07	8.8–27.9	16.70

An analysis of the data in this table shows that the greatest difference of 8.5 μ in the mean spore lengths occurs between spores from Maine on *J. horizontalis* and spores from South Carolina on *J. virginiana*. In the width measurements, the spores from South Carolina and those from Colorado on *J. scopulorum* have the same mean, and the greatest variation from these (1.2 μ) is in the spores from North Carolina on *J. virginiana*. There is certainly no evidence in Table 4 to show that *G. juvenescens* is different from *G. nidus-avis* when the mean lengths of the spores on *J. virginiana* var. *crebra* from Massachusetts differs only by 1.4 μ from those on *J. scopulorum* from Colorado, and the mean widths differ only 0.8 μ; the first comparison in the spores from the north and south seems to bear out Dr. Long's argument, yet even this is invalidated when an analysis of the data in Table 5 is made.

For the data in Table 5, the lengths and widths of fifty spores from telia on *J. virginiana* var. *crebra* were measured from each of twelve stations in Massachusetts. The telia are different from any used for the data in Table 4. All twelve stations are within a twenty-mile radius of Boston. First, it will be noted that there is nearly as great a spread in the mean lengths and widths of the spores produced on the one host within a limited area as was found throughout the whole geographic or host range of *G. nidus-avis*. Next, it can be seen that there is as large a difference (8.5 μ) in the lengths of the spores from Newton and Canton, which are only about ten miles apart, as there is between the spores from South Carolina and Massachusetts to which attention was called in the preceding table. Therefore it may be concluded that *G. juvenescens* cannot be distinguished

TABLE 5. THE SIZE OF TELIOSPORES FROM *Juniperus virginiana* VAR. *crebra* IN EASTERN MASSACHUSETTS

Station	Spore Lengths in μ	Mean Lengths μ	Spore Widths in μ	Mean Widths μ
Beverly	28.5–53.8	39.21	14.2–23.7	17.51
Medford	23.7–55.4	41.45	14.2–23.7	18.03
Brighton	23.7–45.9	36.86	11.1–31.6	20.41
Newton	22.1–42.7	34.96	15.8–25.3	20.25
Hammond's Pond Brookline	31.6–44.3	36.70	12.7–28.5	18.98
Chestnut Hill Brookline	25.3–49.0	39.39	11.1–23.7	18.82
Waltham	31.6–50.6	39.36	15.8–25.3	18.67
Jamaica Plain	26.9–44.3	36.38	15.8–23.7	18.04
Quincy	31.6–55.4	43.19	14.2–30.1	20.41
Walpole	25.3–50.6	37.02	14.2–26.9	20.41
Canton	31.6–53.8	43.51	14.2–28.5	19.78
Sharon	26.9–57.0	39.23	14.2–25.3	19.93
	Total Range in Spore Lengths	Mean Length	Total Range in Spore Widths	Mean Width
	22.1–57.0	38.76	11.1–31.6	19.30

from *G. nidus-avis* on teliospore size and neither can the southern rust be differentiated from the northern rust by this method. The total range in the teliospore lengths and widths of *G. nidus-avis*, then, may be said to vary from 19.1–60.2 μ x 8.8–31.6 μ, with a mean length of 37.9 μ and a mean width of 18.0 μ. In addition, after a comparison of average spore measurements in Tables 4 and 5, of the Massachusetts material, it can be seen that spore measurements from a single specimen or even one locality are not enough to give an accurate representation of spore size. For example, 35.8 x 17.0 μ (Table 4) is the average spore size for Massachusetts material because specimens from throughout the state have been included, whereas 38.8 x 19.3 μ, (Table 5) is representative of spores from only the eastern portion of the state. Moreover, neither of these are as accurate for the species as a whole as 37.1 x 16.7 μ in Table 4, this being the average size of spores from throughout the geographic range of the fungus.

THE HOSTS AND THEIR RELATIVE SUSCEPTIBILITY TO *G. NIDUS-AVIS*

Among the many problems facing the phytopathologists are the subjects of immunity and susceptibility of potential or actual phanerogamic hosts of the various rusts. The importance of these studies may be realized when it is noted that the alternation of hosts in the life cycles of some rusts gives the phytopathologist one of the few means of control of these fungi, since by removing one of the hosts to a safe distance, the alternate host

may be protected to a great extent. For this reason, then, the present studies were undertaken in order to determine what hosts are most susceptible to attack by the fungus and which are resistant or immune. From the information obtained during this study, it is now possible to state definitely which pomaceous trees may be grown near the *Juniperus* species and which are susceptible to *G. nidus-avis* and, therefore, unsuited for ornamental use. Thus the matter of planting horticultural projects may be undertaken with a degree of foresight not previously possible and with a consequent reduction of waste effort.

As far as can be determined from the literature, only a limited number of investigations have been carried out in order to determine the host plants of *G. nidus-avis*. The earliest records that we have are those of Farlow and Thaxter. Following these earliest records are those of Arthur, Kern and others who have increased the list of susceptible hosts. A summary of these investigations is given in Table 6.

In the above table the results of previous experiments on both *G. nidus-avis* and *G. juvenescens* have been tabulated in parallel columns to facilitate comparison. It can be seen that according to previous investigations it was thought that *G. nidus-avis* could be distinguished from *G. juvenescens* on only four hosts: *Crataegus Pringlei* and *Malus coronaria* as hosts of *G. nidus-avis* but not of *G. juvenescens*, and *Amelanchier intermedia* and *Sorbus americana* as hosts of *G. juvenescens* but not of *G. nidus-avis*. These and other purported differences have been considered sufficient to keep these two species distinct. However, it should be pointed out that when the results of different investigators are compared, there is an inconsistency which makes one question the advisability of such a distinction. It only needs to be pointed out that Prince and Steinmetz (1940) were able to inoculate successfully *Cydonia oblonga* with spores of *G. juvenescens* whereas Arthur (1912) was not. Similarly with *Malus pumila* var. *Wealthy*, Clinton and McCormick (1924) were able to obtain infection while Prince and Steinmetz were not, yet the writer in subsequent experiments was successful with his inoculations on this host.

In addition to the above brief discussion of previous investigations, it seems desirable to give a complete list of the pomaceous hosts of *G. nidus-avis* which includes those reported also for *G. juvenescens*.

Farlow and Thaxter, the two original investigators, were able to culture the rust successfully on only *Amelanchier canadensis* (L.) Medic., and an undetermined species of the same genus. Arthur, who reported cultures extending over the period from 1907 to 1915, successfully inoculated *Amelanchier erecta* Blanchard, *A. intermedia* Spach. *A. ovalis* Med., *Cydonia oblonga* Mill., *Crataegus Pringlei* Sarg., *Malus coronaria* (L.) Mill., *M. ioensis* (Wood) Brit., *M. pumila* Mill. var. *Whitney Crab*, and *Sorbus americana* Marsh. Kern (1911) reported additional hosts without cultures. They are *Amelanchier alnifolia* Nutt., *A. florida* Tindl., *A. oreophila* Nels., *A. polycarpa* Greene, and *A. pumila* Nutt. *G. nidus-avis* was reported by the same author as cultured on *Amelanchier vulgaris* Moench. Davis

TABLE 6

HOSTS	INVESTIGATORS	DATE	G.NIDUS-AVIS	G.JUVENESCENS	DATE	INVESTIGATORS
Amelanchier						
alnifolia				+	1924	Fraser
canadensis	Thaxter	1887	+	+	1907	Arthur
"	Thaxter	1889	+	+	1908	Arthur
"	Arthur	1910	-			
"	Dodge	1918	+			
"	Prince & Steinmetz	1940	+			
erecta	Arthur	1912	+	+	1909	Arthur
"	Arthur	1915	-	+	1912	Arthur
intermedia	Arthur	1908	+	+	1908	Arthur
laevis	Prince & Steinmetz	1940	+			
oblongifolia				+	1918	Davis
ovalis	Arthur	1912	+			
"	Arthur	1915	+			
stolonifera	Prince & Steinmetz	1940	+			
canadensis x A. stolonifera	Prince & Steinmetz	1940	+			
Wiegandii	Prince & Steinmetz	1940	+			
Aronia						
arbutifolia	Thaxter	1887	-			
melanocarpa				-	1907	Arthur
Chaenomeles						
japonica	Prince & Steinmetz	1940	-	-	1907	Arthur
Cydonia						
oblonga	Arthur	1912	+	-	1912	Arthur
"	Clinton & McCormick	1924	+			
"	Prince & Steinmetz	1940	+			
Crataegus						
coccinea	Thaxter	1889	-			
Pringlei	Arthur	1910	+	-	1907	Arthur
Malus						
coronaria	Arthur	1912	+	-	1912	Arthur
ioensis	Arthur	1910	+			
"	Clinton & McCormick	1924	+			
pumila	Thaxter	1887	-			
pumila var. Wealthy	Clinton & McCormick	1924	+			
pumila var. Wealthy	Prince & Steinmetz	1940	-			
pumila var. Whitney Crab	Arthur	1908	+			
Sorbus						
americana	Farlow	1886	-	+	1907	Arthur
"	Thaxter	1887	-	+	1909	Arthur
"	Thaxter	1889	-			
"	Prince & Steinmetz	1940	-			

(1918 unpublished) cultured the rust on *A. oblongifolia* Roem. Dodge (1918b) successfully inoculated undetermined species of *Amelanchier* and *Malus*. Clinton and McCormick (1924) cultured the rust on leaves of *Malus pumila* Mill. var. *Wealthy* in Petri dishes. Fraser (1925) successfully inoculated *Amelanchier alnifolia* Nutt. Arthur (1934) added to the host list without reference to cultures *Amelanchier Bakeri* Greene and *A. humilis* Wieg. Crowell (1940) reported *Malus fusca* (Raf.) Schneid.

while Prince and Steinmetz (1940) supplemented the host list of *G. nidus-avis* by means of cultures on *A. laevis* Wieg., *A. stolonifera* Wieg., and *A. Wiegandii* Nielsen.

In a consideration of the above data it is possible to state that *G. juvenescens* as a distinct species does not have a firm foundation, thus substantiating the conclusion arrived at as a result of the morphologic and biometric studies. However, the conflicting data already mentioned indicated the desirability of carrying on the investigations under conditions that were as near alike as possible. The facilities and extensive collection of living pomaceous hosts in the Arnold Arboretum of Harvard University offered an excellent opportunity to round out adequately our knowledge of the variation in susceptibility of the pomaceous plants.

As a source of inoculum, material was obtained from the following hosts and localities: — *Juniperus virginiana* var. *crebra* from Canton, Waltham, and Barnstable, Massachusetts; *J. virginiana* from Chapel Hill, North Carolina, Clemson, South Carolina, and Knoxville, Tennessee; *J. horizontalis* infected with the rust was obtained from Bar Harbor, Maine, and from Saskatoon, Saskatchewan. Brooms caused by the fungus on *Juniperus scopulorum* were obtained from Fort Collins, Colorado.

Immediately after collection or on arrival by post, the telial material was placed in a refrigerator which was maintained at a temperature of about 6° C. Under these conditions teliospores of New England material, freshly collected, would retain their viability up to six weeks. The teliospores of the southern material received by post, however, retained their maximum viability for only four weeks. After five weeks less than 50% of them would germinate. This fact made it necessary in the latter instance to use cuttings and potted plants forced in the greenhouse for inoculation experiments, because the spring season at the stations in the South from which the telia were sent was more than four weeks in advance of the spring season in Massachusetts. Cuttings were tried but they were not found to be satisfactory even though infection was obtainable on susceptible plants. For this reason potted plants of *Amelanchier stolonifera* and potted grafts of *Malus pumila* var. *Wealthy* were prepared in numbers for use during these investigations. These two hosts were chosen because in previous experiments the former was found to have been susceptible in all trials, the latter, because there was a question as to its actually being a host of *G. nidus-avis*.

The inoculum was prepared some time before it was to be used. Tests were made by observing the germination of spores in Van Tieghem cells or by observing the amount of germination of the teliospores just before the inoculum was used. Usually the latter method was followed because the percentage of viability of the teliospores when left *en masse* was more accurate than when the spores were separated and placed in Van Tieghem cells.

The inoculum was made by thoroughly wetting with distilled or rain water, the telial material to be used, and then placing the telia in a moist

container for at least two hours. Often material to be used for a forenoon's inoculations was prepared late the night before and left under cool conditions, that is, at 18 to 20° C. and by morning basidiospores would begin to appear. When cultures were to be made in the afternoon, telial material was placed in moist chambers early the same day, thus keeping a careful check on all inoculum used. When ready for use, a thick suspension of germinating teliospores was made in small, wide-mouthed, stoppered bottles from which inoculum was removed and painted on both sides of the leaves or on the surface of the fruits when the latter were present. All of the inoculated branches were protected during the infection period with celluloid cylinders similar to those described by Hubert (1916) but *Sphagnum* was used to plug the ends instead of cotton, and the chambers were then covered with paper bags after which the inoculated branches were marked with numbered tags. The paper bags served a twofold purpose. They protected the inoculated plant parts from the direct rays of the sun and prevented rapid evaporation from the *Sphagnum* plugs. Normally the chambers were allowed to remain in place from thirty-six to seventy-two hours, but during the unseasonably cold weather in the spring of 1940, they were left on for five days without causing injury to covered plant parts. After the chambers were removed, the suscepts were examined at frequent intervals until ready for collection, or until the subject was considered to be immune. In most cases, the plants listed as immune were observed for four weeks before a decision was made.

THE DETERMINATION OF VARIATION IN HOST SUSCEPTIBILITY

Considerable work has been done from the time of De Bary up to the present to determine the variation in susceptibility of economic plants to rust diseases, but nothing has been recorded as to the variation in susceptibility of pomaceous hosts of *Gymnosporangium nidus-avis*.

To express my observations with respect to this phenomenon, standards were established according to which data were recorded for these susceptibility studies. Five arbitrary categories were adopted; they are similar to those employed by other uredinologists but differ, through necessity, in some details. Their designations and descriptions follow: (1) *Immune*. No evidence of infection observed. (2) *Very resistant*. Necrotic spots produced, usually with some abortive spermogonia, always without aecia; the presence of an invasion zone clearly evident in a transverse section of the leaf (Plate I, Fig. 4). (3) *Resistant*. Lesions sometimes becoming necrotic; spermogonia and aecia taking longer to develop than on the more susceptible hosts. (4) *Susceptible*. Spermogonia forming within twelve days, aecia within four to five weeks; a few lesions occasionally becoming abortive or even necrotic; lesions with an average of one to five aecia. (5) *Very susceptible*. Time for the development of spermogonia and aecia about the same as in four; no lesions becoming necrotic; lesions with an average of six or more aecia.

As a result of the writer's investigation with artificial inoculations made in the Arnold Arboretum, it is now possible to add to the already rather extensive host list. These new hosts are *Amelanchier amabilis* Wieg., *A. asiatica* (Sieb. and Zucc.) Endl. var. *sinica* Schneid., *A. Bartramiana* (Tausch) Roem. x *A. laevis* Wieg., *A. florida* Lindl., *A. grandiflora* Rehder forma *rubescens* Rehder, *A. oblongifolia* Roem. var. *micropetala* Robins., *A. sanguinea* (Pursh) DC., *A. sera* Ashe, *A. spicata* (Lam.) K. Koch, *Amelosorbus Jackii* Rehder, *Chaenomeles lagenaria* (Thunb.) Lindl., *C. superba* (Frahm) Rehder, *Sorbaronia Dippelii* (Zab.) Schneid., *Sorbus americana* Marsh., *S. americana* var. *fructo-albo* auct., *S. americana* Marsh. var. *micrantha* Dum.-Cours., *S. Aria* (L.) Crantz var. *salicifolia* auct., *S. aucuparia* L., *S. aucuparia* L. var. *edulis* Dieck, *S. aucuparia* L. var. *xanthocarpa* Hartw. and Ruempl., *S. discolor* (Maxim.) Hedl., *S. japonica* (Decne.) Hedl. var. *callocarpa* Rehder, *S. latifolia* (Lam.) Pers., *S. scopulina* Green, and *S. thuringiaca* (Ilse) Fritsch.

It became obvious during the progress of this investigation that there were considerable variations in the degree of susceptibility of some of the hosts, not only in the different host species but also in different plants belonging to the same species. For this reason, all of the plants inoculated and found to be susceptible in some degree are listed in Appendix I and the variations in the susceptibilities of the hosts are indicated by symbols. The origin of the telia used for inoculum is shown with reference to host and geographical station.

Some plants, as *Amelanchier canadensis*, *A. humilis*, *A. sanguinea*, *A. sera*, *A. stolonifera*, *Chaenomeles lagenaria*, and *Sorbus scopulina* were found to exhibit the same degree of susceptibility to *G. nidus-avis* regardless of range of telial host. Other plants, however, show a variation in their reaction to the fungus. The cultures on *Amelanchier amabilis* tend to separate the eastern rust from the western. This host was found to be susceptible to the rust from Colorado and Saskatchewan, but was resistant to the rust from Maine, and immune to the rust from Massachusetts. The fact that there was a difference in the degree of susceptibility of the aecial host when it was inoculated with spores from widely separated localities, strongly suggests that different strains of the fungus have arisen through geographic segregation. Additional evidence of this is shown by inoculations on *Amelanchier grandiflora* forma *rubescens*, *A. oblongfolia*, *A. spicata*, *Amelosorbus Jackii*, *Sorbus americana* and other species listed in Appendix I.

The segregation of geographic strains is only one factor. A complication results from the fact that there is also evident a tendency for basidiospores from a given telial host to infect one pomaceous host to a different degree than do the basidiospores from another telial host. Here then is evidence of fungus strains. Thus, according to the results in Appendix I the rust strain on *Juniperus virginiana* can be distinguished on *Amelanchier asiatica* var. *sinica*, *A. Bartramiana* x *A. laevis*, and *Sorbus japonica* var. *callocarpa*. Similarly, the strain from *Juniperus horizontalis* can be separated on

Sorbus americana var. *micrantha* and *Amelosorbus Jackii.* Finally, the strain on *Juniperus scopulorum* can be separated on *Amelanchier florida, Amelosorbus Jackii,* and *Cydonia oblonga.*

While there is evidence that there is some host specialization, it does not seem that this should be taken to indicate the desirability of erecting large numbers of strains as has been done for the graminicolous species of rusts. In addition another examination of Table 6 shows clearly that experiments with a limited number of hosts may lead to false conclusions. Examples of this are shown by the inoculations on three plants of *Amelanchier spicata* numbers 5215–A, 12635–A, and 12635–C. In this instance *A. spicata* 5215–A is immune to the spores from *Juniperus horizontalis* from Maine, but is susceptible to infection by spores from the same host from Saskatchewan. On the other hand, *Amelanchier spicata* 12635–A and 12635–C are offspring from the same parent. This shows a variation in the susceptibility within an individual host species. The same phenomenon is shown in the hybrid *Chaenomeles superba* 13017 and 18184, and in the species *Sorbus aucuparia* 17264–A, 17682–D, 17682–C, and 17266–E. The concept is thus made more confusing by the fact that individual host species show variations in the degree of susceptibility.

In spite of the confusion that seems to be added by the factor of individual host variation in susceptibility, it is possible to coordinate these variables if we consider the average of all of the inoculated susceptible hosts to inocula from the four geographic regions. In addition, there is confirmation of the supposition that there are different strains of *G. nidus-avis.* Data showing the average degree of susceptibility of all the susceptible hosts that were inoculated are given in Table 7.

TABLE 7

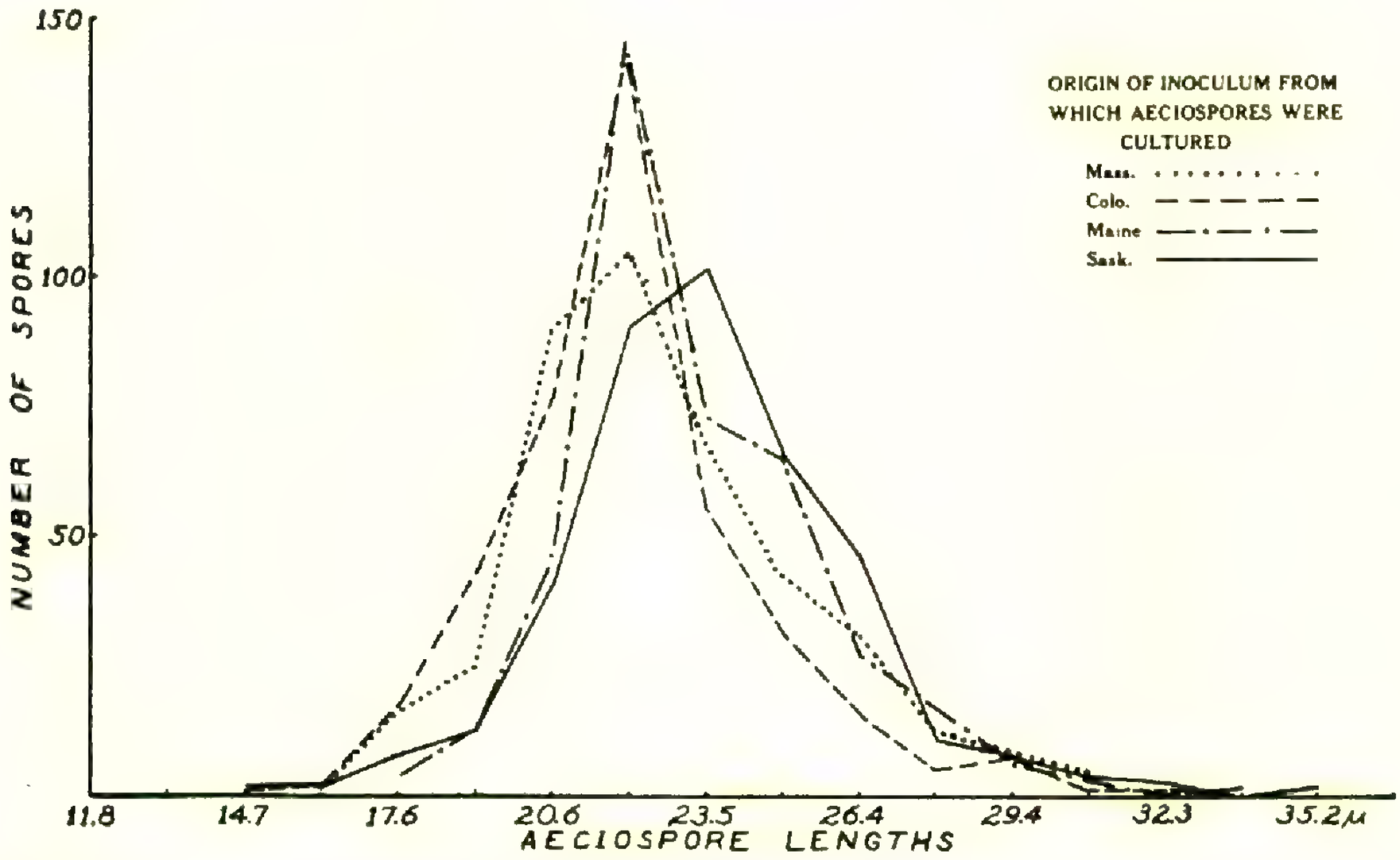
TABLE 7. DATA SHOWING THE AVERAGE DEGREE OF SUSCEPTIBILITY OF ALL OF THE INOCULATED SUSCEPTIBLE HOSTS TO FOUR DIFFERENT INOCULA

Telial Hosts	*J. virginiana*	*J. scopulorum*	*J. horizontalis*	*J. horizontalis*
Origin of Inoculum	Mass.	Colo.	Maine	Sask.
Degree of Susceptibility of Aecial Hosts	Percent	Percent	Percent	Percent
Very Susceptible	0	2	0	3
Susceptible	40	44	32	46
Resistant	19	10	26	21
Very Resistant	15	15	7	9
Immune	26	29	35	21

The above values mean that 2% of the inoculated plants were very susceptible to the rust from *Juniperus scopulorum,* 44% were susceptible, 10% were resistant, 15% were very resistant, and 29% were immune.

These data show that degrees of susceptibility or resistance are of the same order for all of the different inocula, but a slightly greater percentage of the hosts were immune to the inoculum from Maine than to the inocula from the other three stations. This confirms my interpretation of the data presented in the preceding table, that there is evidence of host and geographical strains of *G. nidus-avis*. There is also a slight variation in the degrees of susceptibility of the hosts to inocula from Massachusetts and Colorado, and Colorado and Saskatchewan. In addition, although the values given in Table 7 are expressed in the degrees of susceptibilities of the plants to the fungus, these values may also be interpreted as the ability of the fungus to attack these various hosts, since the same plants were used throughout.

The differences shown, even though slight, indicate that there is some



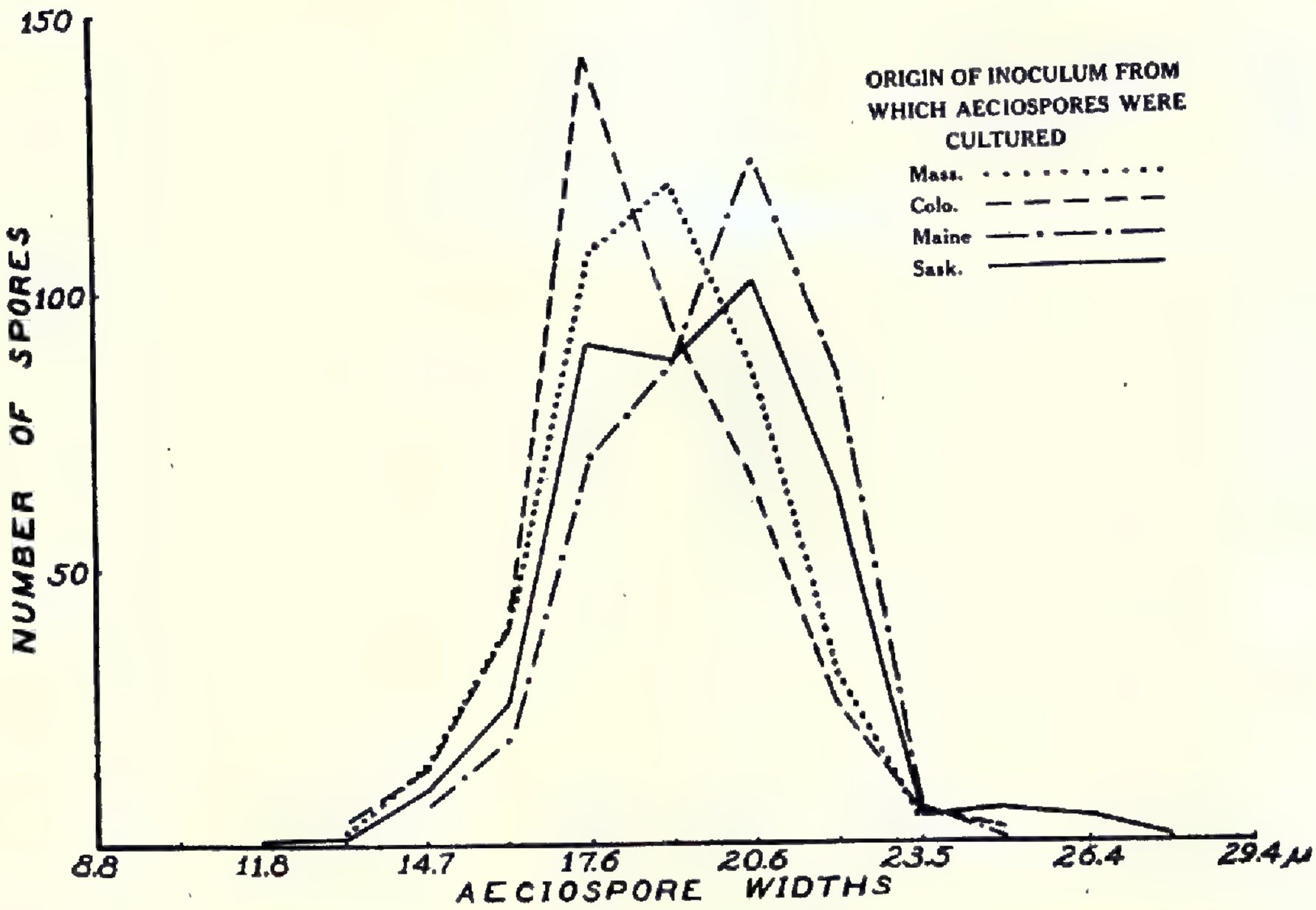
GRAPH A. A Comparison of Aeciospore Lengths. Aeciospores Cultured on Similar Hosts with Inoculum from Four Localities

variation in the virulence of these inocula when they are placed on the various hosts. There is still additional evidence of the presence of biological strains within *G. nidus-avis* to be found in the time necessary for development of the spermogonia and aecia. The data concerning this are presented in Table 8. Again the amount of variation in the host reaction to the fungus from different areas and different hosts is slight, but the variation, where it exists, indicates the presence of biological strains.

The sizes of the aeciospores furnish evidence of the presence of biological strains. The aeciospores measured came from cultures made with inocula from Maine, Massachusetts, Saskatchewan, and Colorado. The lengths and widths of these aeciospores are compared in Graphs A and B. The aeciospore measurements represented here are taken from the data given in Table 7. In Graph A where the spore lengths are compared, the

Massachusetts strain varies slightly from the Saskatchewan. Those from Maine and Colorado are very similar, but vary slightly from the two preceding strains. There is a greater degree of variability shown in the spore widths than in the lengths. Graph B illustrates this, and shows that the variability is not large enough to change the conclusions already drawn.

Even though the degree of variability shown by these comparisons is small, when one considers this variability and that which exists in the differences in aecial host susceptibility, and in the time of development, and finally, the variability in the manifestation of the symptoms of disease on the telial hosts, the only interpretation that can be advanced is that



GRAPH B. A Comparison of Aeciospore Widths. Aeciospores Cultured on Similar Hosts with Inoculum from Four Localities

there are definitely biological strains of *G. nidus-avis*. However, there is no evidence to show that more than one species is represented here, or that the one species can be separated into varieties or even forms. Certainly *G. juvenescens* has been shown to be morphologically identical with *G. nidus-avis*. More conclusive evidence which bears out this statement is that aeciospores from *Amelanchier grandiflora* forma *rubescens*, which were produced following an inoculation with basidiospores from telia on *Juniperus scopulorum*, were used to inoculate successfully *Juniperus virginiana* var. *crebra*, thus removing any doubt as to the ability of the fungus to infect both coniferous hosts, and thereby establishing the identity of *G. juvenescens* with *G. nidus-avis*.

In addition to the plants found to be susceptible to attack by the fungus, a number of the plants inoculated were found to be entirely immune. From

TABLE 8. A COMPARISON OF THE DEVELOPMENTAL PERIODS OF *G. nidus-avis* ACCORDING TO THE ORIGIN OF INOCULUM AND THE TELIAL HOSTS

Origin of Inoculum and Telial Host	Stage of Rust	First Appearance in Days	Average in Days
Maine	0	9–16	12.7
J. horizontalis	1	28–45	33.0
Saskatchewan	0	9–16	11.8
J. horizontalis	1	25–36	30.5
Colorado	0	10–16	13.3
J. scopulorum	1	25–41	33.7
Massachusetts	0	9–16	12.7
J. virginiana var. *crebra*	1	28–45	33.0
N. Carolina	0	6–14	8.9
J. virginiana	1	32	32
S. Carolina	0	14	14
J. virginiana	1	31–43	33.3
Tennessee	0	10–14	13
J. virginiana	1	31	31

the economic standpoint it is as necessary to know the immune plants as the susceptible. It is certain that any of the plants listed as immune could be planted adjacent to the susceptible species of *Juniperus* without danger of being infected by *G. nidus-avis*. However, persons interested in the planting of these combinations of hosts should keep in mind the works of Crowell (1934a and 1934b) and MacLachlan (1935a and b) who have dealt with other species of *Gymnosporangium* which infect both pomaceous and *Juniperus* hosts, since species found in the present studies to be immune to attack by *Gymnosporangium nidus-avis* may possibly be subject to infection by *G. Juniperi-virginianae*, *G. globosum*, or *G. clavipes*.

ECONOMIC IMPORTANCE AND POSSIBILITIES OF CONTROL

When compared with the three species of *Gymnosporangium* that commonly are called the cedar-apple rusts, *G. nidus-avis* is actually of little economic importance since only under most favorable conditions does it infect the apple trees. Yet even though it is of little importance in orchard practice, it is a fungus that must be taken into consideration by the landscape architect who employs both its aecial and telial hosts for ornamen-

tal plantings, often so close together that heavy cross-inoculations result that may cause severe damage to both hosts.

In the species of *Gymnosporangium* that cause the cedar-apples that are so conspicuous in the spring, it is the aecial hosts that are heavily damaged, whereas in the case of *G. nidus-avis* it is the telial host that suffers most. Dodge (1931, 1934) pointed out that cedars (*Juniperus* spp.) are actually killed following attacks by this rust, but Hartley (1913) indicated that when cedars succumbed following attacks by this rust, it was not the primary cause. Observations by the author support the views of Hartley rather than those of Dodge. It is clear, however, that the rust does cause considerable malformation of seriously infected trees, weakening them, and then by making openings in the protective corky bark, permits the entrance of wood destroying organisms. The most severely infected cedar tree that the author has had occasion to study occurs in the vicinity of Clemson, South Carolina. This tree is about eighty years old, as determined by increment borings, and has more than one hundred brooms. The trunk and branches are infected from the ground line upward so that in the spring when gelatinization of the sori takes place, the tree is nearly covered with the telia. In spite of this heavy infection, however, the tree shows no external symptoms of an early demise but when the increment borings were made, the first ten to fifteen years of annual growth at the center showed evidence of decay. Similarly, in several different localities where branches with brooms have been found dead or dying, the rust did not appear to be the primary cause, although there is the possibility that the fungus mycelium had penetrated beyond the obvious lesions and this in some instances may have resulted in partial girdling that so interfered with the vegetative activities of the broom as to weaken it during conditions that might have been adverse for the tree as a whole. Whatever may have been the cause of the death of the brooms, the result of infection by this fungus is to spoil the appearance by making distorted or malformed trees out of what would otherwise be symmetrical ornamentals.

The only course open to the tree surgeon or landscape gardener after a cedar has become infected, is to remove the broom as early as possible after it has become evident and possibly to remove infected parts near the point of attachment of the broom. Frequently this treatment may be inadvisable when a whole limb must be removed since the loss of a limb may damage the appearance of the tree more than the presence of an infected branch. Thus while tree surgery may in special cases prove to be desirable, the best method for preserving the health and beauty of ornamental cedar trees is to prevent their infection by not planting susceptible alternate hosts within three hundred feet, preferably more, of the host, and to practice control measures such as those suggested for *Gymnosporangium clavipes* by MacLachlan and Crowell (1937). The best method of all, where *Juniperus* and the pomaceous hosts must be planted near each other for desired effects, is to plant only pomaceous

hosts that have been shown to be immune, a list of which will be found in Appendix II. Among the names will be found a variety of shrubs and trees which should permit plantings with *Juniperus* species in almost any habitat and allow considerable latitude in the choice of types of trees.

SUMMARY

The first collection of *Gymnosporangium nidus-avis* was by Ravenel on *Juniperus virginiana* in South Carolina during 1848, while Farlow (1880) was the pioneer contributor to our knowledge concerning it, but not until 1891 did Thaxter establish this rust as a new American species. Arthur and Kern (1908 to 1915), Dodge (1918a–c) and Prince and Steinmetz (1940) were the main contributors to life history studies of this fungus; the latter two authors were unable to distinguish between the western *G. juvenescens* and the eastern *G. nidus-avis*.

A summary of investigations and the results obtained follows:

1. The taxonomy of the fungus has been clarified. As a result of morphological studies and inoculation experiments, it has been conclusively demonstrated that *G. juvenescens* is a synonym of *G. nidus-avis*.
2. The geographic distribution of its telial (*Juniperus*) hosts and aecial (pomaceous) hosts has been determined.
3. The symptomatology of the spermogonial, aecial and telial phases has been defined.
4. Results of studies on the microscopical development and morphology of the vegetative and reproductive phases in the spermogonial, aecial and telial phases are presented in detail.
5. The pomaceous host range and varietal host susceptibility has been clarified as a result of cultures with inoculum from four telial hosts representing seven localities, five eastern and two western.
6. The economic importance is considered, and possibilities of control of the fungus are presented.

ACKNOWLEDGMENTS

It is with sincere pleasure that the author acknowledges his indebtedness to Dr. David H. Linder for his thoughtful guidance and suggestions during the progress of these investigations. The author wishes to express similar appreciation to Professor Emeritus J. H. Faull under whom these studies were initiated and whose special interest made them possible. Acknowledgments are due staff members of the Farlow Herbarium and Reference Library and the Arnold Arboretum for their willing assistance in several phases of the work. Thanks are due the following individuals who kindly supplied fresh telial material for cultures from the stations indicated: A. E. Brower, Bar Harbor, Maine; the late Dr. W. P. Fraser, Saskatoon, Saskatchewan; J. L. Forsberg, Ft. Collins, Colorado; L. R. Hesler, Knoxville, Tennessee; L. S. Olive, Chapel Hill, North Carolina; R. C. Russell, Sas-

katoon, Saskatchewan; L. Shanor, Clemson, South Carolina; and F. H. Steinmetz, Cape Elizabeth and Bar Harbor, Maine. Thanks are due G. G. Hedgcock, Gainesville, Florida, and W. W. Ray, Stillwater, Oklahoma for sending specimens for comparison and especially to G. B. Cummins for the loan of specimens from the Arthur Herbarium at Purdue University, Lafayette, Indiana.

CLEMSON AGRICULTURAL COLLEGE
CLEMSON, SOUTH CAROLINA

APPENDIX I. THE HOSTS OF *G. nidus-avis* AND THEIR VARIATION IN SUSCEPTIBILITY AS DETERMINED BY ARTIFICIAL INOCULATIONS

Hosts	Mass. *J. virginiana* v. *crebra*	Maine *J. horizontalis*	Colo. *J. scopulorum*	Sask. *J. horizontalis*	N. C. *J. virginiana*	S. C. *J. virginiana*
Amelanchier						
alnifolia 15700	S*		S			
amabilis 7058	I	R	S	S		
asiatica						
var. *sinica* 15694–C	R	S	S	S		
Bartramiana						
x *A. laevis* 4405	I	S	S	S		
canadensis 19100–B	S	S	S	S		
florida 11315–A	I	I	VR	I		
grandiflora						
forma *rubescens* 20678–A	S	S	S	VR		
humilis 6817	S	S	S	S		
intermedia 21920–B	S		S			
laevis 21447–B				VS		
laevis P–103–38	S	I	I	I		
oblongifolia 18265–A	S					
oblongifolia 18265–B	R	I	I	R		
oblongifolia						
var. *micropetala* 13192			R			
sanguinea 6620–B	S	S	S	S		
sera 11579	S	S	S	S		
spicata 5215–A	S	I	S	S		
spicata 12635–A	I	I	I	S		
spicata 12635–C	S		S			
stolonifera 644–30	S		S	S	R	
stolonifera (potted)	S	S	S	S	S	S
Amelosorbus						
Jackii 17943–B	R	S	VS	I		
Chaenomeles						
lagenaria 5098	S	S	S	S		
x *superba* 13017	I	I	I	I		
x *superba* 18184	I	I	VR	R		

* S = Susceptible; VS = Very Susceptible; R = Resistant; VR = Very Resistant; I = Immune

Numerals refer to Arnold Arboretum specimen numbers.

APPENDIX I (*continued*)

Hosts	Mass. *J. virginiana* v. *crebra*	Maine *J. horizontalis*	Colo. *J. scopulorum*	Sask. *J. horizontalis*	N. C. *J. virginiana*	S. C. *J. virginiana*
Cydonia						
oblonga 15648	I	VR	S	I		S
oblonga at U. of Me.		R		S		
Malus						
pumila						
var. *Wealthy* (potted)			VR		VR	
Sorbaronia						
Dippelii 170–25	I	I	I	R		
Sorbus						
americana at U. of Me.		I		S		
americana 22831	VR		VR			
americana						
var. *fructo-albo* 20931	VR					
americana						
var. *micrantha* 22381	I	R	I	R		
Aria						
var. *salicifolia* 222–27	VR					
aucuparia 17264–A	R	I	I	R		
aucuparia 17682–D		R		I	I	
aucuparia 17266–E	R	S	S	S		
aucuparia 17682–C	VR	VR	VR	VR		
aucuparia						
var. *edulis* 21427–A	VR	R	R	R		
aucuparia						
var. *xanthocarpa* 224–27	R		I	VR		
discolor 108–29–B	S	R	S	S		
discolor 20010	R	R	I	S	R	
discolor 21426–A				R		
japonica						
var. *callocarpa* 7703	S	I	I	I		
latifolia 19861–A	VR		VR			
scopulina 18452	R	R	R	R		
x *thuringiaca* 19847	R		I	I		
x *thuringiaca* 19847–B	I	R	R	R		
Number species and varieties inoculated	42	34	41	37	5	2

* S = Susceptible; VS = Very Susceptible; R = Resistant; VR = Very Resistant; I = Immune

Numerals refer to Arnold Arboretum specimen numbers.

APPENDIX II. A LIST OF PLANTS INOCULATED AND FOUND TO BE IMMUNE TO *Gymnosporangium nidus-avis*

Aronia
arbutifolia (L.) Elliott
arbutifolia (L.) Elliott forma *macrophylla* (Hook.) Rehder
melanocarpa (Michx.) Elliott
prunifolia (Marsh.) Rehder

Chaenomeles
japonica (Thunb.) Lindl.

Cotoneaster
tomentosa (Ait.) Lindl.

Crataegomespilus
grandiflora (Sm.) Bean

Crataegus
austromontana Beadle
Brittonii Eggl.
chrysocarpa Ashe
coccinioides Ashe
crus-galli L.
Douglasii Lindl.
fecunda Sarg.
Fischeri Schneid.
Holmesiana Ashe
intricata Lange
macrosperma Ashe
micracantha Sarg.
mollis Scheele
Oxyacantha L.
phaenopyrum (L.f.) Medic.
Pringlei Sarg.
pruinosa (Wendl.) K. Koch
punctata Jacq.
rivularis Nutt.
scabrida Sarg.
spathulata Michx.
viridis L.

Malus
angustifolia (Ait.) Michx.
arnoldiana (Rehder) Sarg.
astracanica Dum.-Cours.
baccata (L.) Borkh.
baccata (L.) Borkh. var. *Dartmouth Crab*
bracteata Rehder
coronaria (L.) Mill.
coronaria (L.) Mill. var. *elongata* Rehder
fusca (Raf.) Schneid.
glabrata Rehder
ioensis (Wood) Brit.
ioensis (Wood) Brit. forma *plena* (Schneid.) Rehder
lancifolia Rehder
x "Mathews Crab"
platycarpa Rehder
prunifolia (Wild.) Berkh. var. *fructu-coccinea* auct.
pumila Mill.
Sargenti Rehder
Sieboldii (Reg.) Rehder
Soulardii (Bailey) Brit.
spectabilis (Ait.) Borkh.
sylvestris Mill.
Zumi (Mats.) Rehder var. *calocarpa* (Rehder) Rehder

Mespilus
germanica L.

Photinia
villosa (Thunb.) DC. var. *sinica* Rehder & Wilson

Pyrus
amygdaliformis Vill. var. *cuneifolia* (Guss.) Bean
communis L.
nivalis Jacq.
Pashia D. Don
phaeocarpa Rehder
serrulata Rehder
syriaca Boiss.
ussuriensis Maxim. var. *hondoensis* (Kikuchi & Nakai) Rehder

Sorbopyrus
auricularis (Knoop) Schneid. var. *bulbiformis* (Tatar) Schneid.

Sorbus
alnifolia (Sieb. & Zucc.) K. Koch
americana Marsh. var. *nana* auct.
Aria (L.) Crantz
commixta Hedl.
decora (Sarg.) Schneid.
hybrida L.
intermedia (Ehrh.) Pers.
latifolia (Lam.) Pers.
Matsumurana (Mak.) Koehne
pohuashanensis (Hance) Hedl.
rufo-ferruginea (Schneid.) Schneid.

LITERATURE CITED

Allen, Ruth F. 1930. A cytological study of heterothallism in *Puccinia graminis*. Jour. Agr. Res. **40:** 585–614.

———. 1932. A cytological study of heterothallism in *Puccinia coronata*. Jour. Agr. Res. **45:** 513–541.

Arthur, J. C. 1901 a. Generic nomenclature of cedar apples. Proc. Ind. Acad. Sci. 1900: 136.

———. 1901 b. New species of Uredineae — I. Bull. Torrey Bot. Club **28:** 665.

———. 1907. Cultures of Uredineae in 1906. Jour. Myc. **13:** 203.

———. 1908. Cultures of Uredineae in 1907. Jour. Myc. **14:** 18.

———. 1909. Cultures of Uredineae in 1908. Mycologia **1:** 239–240.

———. 1910. Cultures of Uredineae in 1909. Mycologia **2:** 213–240.

———. 1912 a. Cultures of Uredineae in 1910. Mycologia **4:** 26.

———. 1912 b. Cultures of Uredineae in 1911. Mycologia **4:** 61–63.

———. 1915. Cultures of Uredineae in 1912, 1913, and 1914. Mycologia **7:** 61–89.

———. 1934. Manual of the Rusts in United States and Canada. Lafayette, Indiana.

Bliss, D. E. 1931. Physiologic specialization in *Gymnosporangium*. Phytopath. **21:** 111.

———. 1933. The pathogenicity and seasonal development of *Gymnosporangium* in Iowa. Iowa Agr. Exp. Sta. Bull. 106: 340–392.

Clinton, G. P. & Florence A. McCormick. 1924. Rust infection of leaves in Petri dishes. Conn. Agr. Exp. Sta. Bull. 260: 492.

Coker, W. C. 1920. Notes on the lower Basidiomycetes of North Carolina. Jour. E. Mitchell Sci. Soc. **35:** 118.

Colley, R. H. 1925. A biometric comparison of the Urediniospores of *Cronartium ribicola* and *Cronartium occidentale*. Jour. Agr. Res. **30:** 283–291.

Coons, G. H. 1912. Some investigations of the cedar rust fungus, *Gym. juniperi-virginianae*. Neb. Agr. Exp. Sta. Rept. 25: 215–245.

Craigie, J. H. 1927. Discovery of the function of pycnia of the rust fungi. Nature **120:** 765–767.

Crowell, I. H. 1934 a. The hosts, life history and control of the cedar-apple rust fungus, *Gymnosporangium juniperi-virginianae* Schw. Jour. Arnold Arb. **15:** 165–232.

———. 1934 b. The hosts, life history and control of *Gymnosporangium clavipes* C. & P. Jour. Arnold Arb. **16:** 368–409.

———. 1940. The geographical distribution of the genus *Gymnosporangium*. Can. Jour. Res. 18: 469–488.

Curtis, M. A. 1867. Geological and Natural History Survey of North Carolina. Pt. III. Botany. p. 121. Raleigh, N. C.

Dodge, B. O. 1918 a. Studies in the genus *Gymnosporangium*. I. Mem. Brooklyn Bot. Gard. **1:** 128–140.

———. 1918 b. Studies in the genus *Gymnosporangium*. II. Bull. Torrey Bot. Club **45:** 294–295.

———. 1918 c. Studies in the genus *Gymnosporangium*. III. Mycologia **10:** 182–193.

———. 1931. A destructive red-cedar rust disease. Jour. N. Y. Bot. Gard. **32:** 101–108.

———. 1934. Witches' brooms on southern white cedar. Jour. N. Y. Bot. Gard. **35:** 41.

Farlow, W. G. 1880. The Gymnosporangia or cedar apples of the United States. Anniv. Mem. Boston Soc. Nat. Hist. pp. 1–38. pl. 1–2.

———. 1886 a. Development of Roestelia from Gymnosporangia. Bot. Gaz. **11:** 189–190.

———. 1886 b. The development of the Gymnosporangia of the United States. Bot. Gaz. **11:** 234–241.

———. 1905. Bibliographical Index of North American Fungi. **1:** 68. Carnegie Inst. Washington, D. C.

Fernald, M. L. & L. Griscom. 1935. Three days of botanizing in southeastern Virginia. Rhodora **37:** 131–133. pl. 332–333.

Fischer, Ed. 1891. Über *Gymnosporangium Sabinae* (Dicks.) and *Gymnosporangium confusum* (Plowright). Zeitschr. Pflanzenkr. **1:** 271.

———. 1895. Die Zugehörigkeit von *Aecidium penicillatum*. Hedwigia **34:** 1–6.

Fraser, W. P. 1925. Culture experiments with heteroecious rusts in 1922, 1923, and 1924. Mycologia **17:** 84.

Giddings, N. J. 1918. Infection and immunity in apple rust. W. Va. Agr. Exp. Sta. Bull. 170: 9.

Hartley, C. 1913. Bark rusts of *Juniperus virginiana*. Phytopath. **3:** 249.

Hedgcock, G. G. 1940. Notes on distribution of fungi collected in southeastern United States in 1938 and 1939. U. S. Dept. Agr. Plant Dis. Rept. **24:** 322.

Hubert, E. E. 1916. Celluloid cylinders for inoculation purposes. Phytopath. **6:** 447–450.

Hunter, Lillian M. 1936. Morphology and ontogeny of the spermogonia of the Melampsoraceae. Jour. Arnold Arb. **17:** 115–132.

Kern, F. D. 1910. The morphology of peridial cells of the *Roesteliae*. Bot. Gaz. **49:** 445–452.

———. 1911. A biologic and taxonomic study of the genus *Gymnosporangium*. Bull. N. Y. Bot. Gard. **7:** 391–483.

———, **H. W. Thurston, C. R. Orton, & J. F. Adams.** 1929. The rusts of Pennsylvania. Penn. Agr. Exp. Sta. Tech. Bull. 239: 20.

Levine, M. N. 1923. A statistical study of the comparative morphology of biologic forms of *Puccinia graminis*. Jour. Agr. Res. **24:** 539–567.

MacLachlan, J. D. 1935 a. The hosts of *Gymnosporangium globosum* Farl. and their relative susceptibility. Jour. Arnold Arb. **16:** 98–142.

———. 1935 b. The dispersal of viable basidiospores of the *Gymnosporangium* rusts. Jour. Arnold Arb. **16:** 411–422.

———. 1936. Studies on the biology of *Gymnosporangium globosum* Farl. Jour. Arnold Arb. **17:** 1–24.

———, **& I. H. Crowell.** 1937. Control of the *Gymnosporangium* rusts by means of sulphur sprays. Jour. Arnold Arb. **18:** 149–163.

Maerz, A. & M. R. Paul. 1930. A Dictionary of Color. New York.

Millspaugh, C. F. & L. W. Nuttall. 1896. Flora of West Virginia. Publ. Field Mus. Bot. Ser. **1:** 129.

Munns, E. N. 1938. The distribution of important forest trees of the United States. U. S. D. A. Misc. Publ. **287:** 63.

Palmer, E. J. 1925. Synopsis of North American *Crataegus*. Jour. Arnold Arb. **6:** 5–28.

Prince, A. E. 1943. Basidium formation and spore discharge in *Gymnosporangium nidus-avis*. Farlowia **1:** 79–93.

———, **& F. H. Steinmetz.** 1940. *Gymnosporangium* rusts in Maine, and their host relationships. Univ. Me. Stud. 2d Ser. No. 50: 3–10.

Rathay, E. 1883. Untersuchungen über die Spermogonien der Rostpilze. Denkschr. K. Akad. Wiss. Wien. Mat.-Nat. Kl. Abt. 2. **46:** (1–51) 22–23.

Ray, W. W. 1940. Notes on *Gymnosporangium* in Oklahoma. Mycologia **32:** 572.

Rehder, A. 1940. Manual of Cultivated Trees and Shrubs. New York.

Sudworth, G. 1915. The cypress and juniper trees of the Rocky Mountain Region. U. S. D. A. Dept. Bull. 207.

Thaxter, R. 1887. VII. On certain cultures of *Gymnosporangium* with notes on their Roesteliae. Proc. Amer. Acad. Arts and Sci. **22:** 259–268.

———. 1889. Notes on cultures of *Gymnosporangium* made in 1887 and 1888. Bot. Gaz. **14:** 163–172.

———. 1891. The Connecticut species of *Gymnosporangium* (cedar apples). Conn. Agr. Exp. Sta. Bull. 107: 2–6.

———. 1892. The Connecticut species of the *Gymnosporangium* (cedar apples). Conn. Agr. Exp. Sta. Rept. 1891: 164.

———. 1893. Fungi described in recent reports of the Connecticut Experiment Station. Jour. Myc. **7:** 278–280.

Weimer, J. L. 1917. Three cedar rust fungi. Their life histories and the diseases they produce. Cornell Univ. Agr. Exp. Sta. Bull. 390: 523–524.

EXPLANATION OF PLATE I

Fig. 1. Leaves and fruit of *Amelosorbus Jackii* infected by *G. nidus-avis*, the abundant, large lesions indicating the extreme susceptibility to inoculum from Colorado.

Fig. 2. Leaves and stems of *Amelanchier canadensis* bearing numerous aecia, evidence that this host is very susceptible to *G. nidus-avis* from Saskatchewan, Canada.

Fig. 3. Portion of a cross section of a leaf of *Amelanchier stolonifera*, illustrating amphigenous spermogonia of *G. nidus-avis*.

Fig. 4. Invasion zone bordering healthy tissue in portion of Wealthy apple leaf section. Note abortive spermogonium.

Fig. 5. A longitudinal section of a single spermogonium showing a darkly stained receptive hypha among the periphyses.

Fig. 6. A longitudinal section of a young aecium.

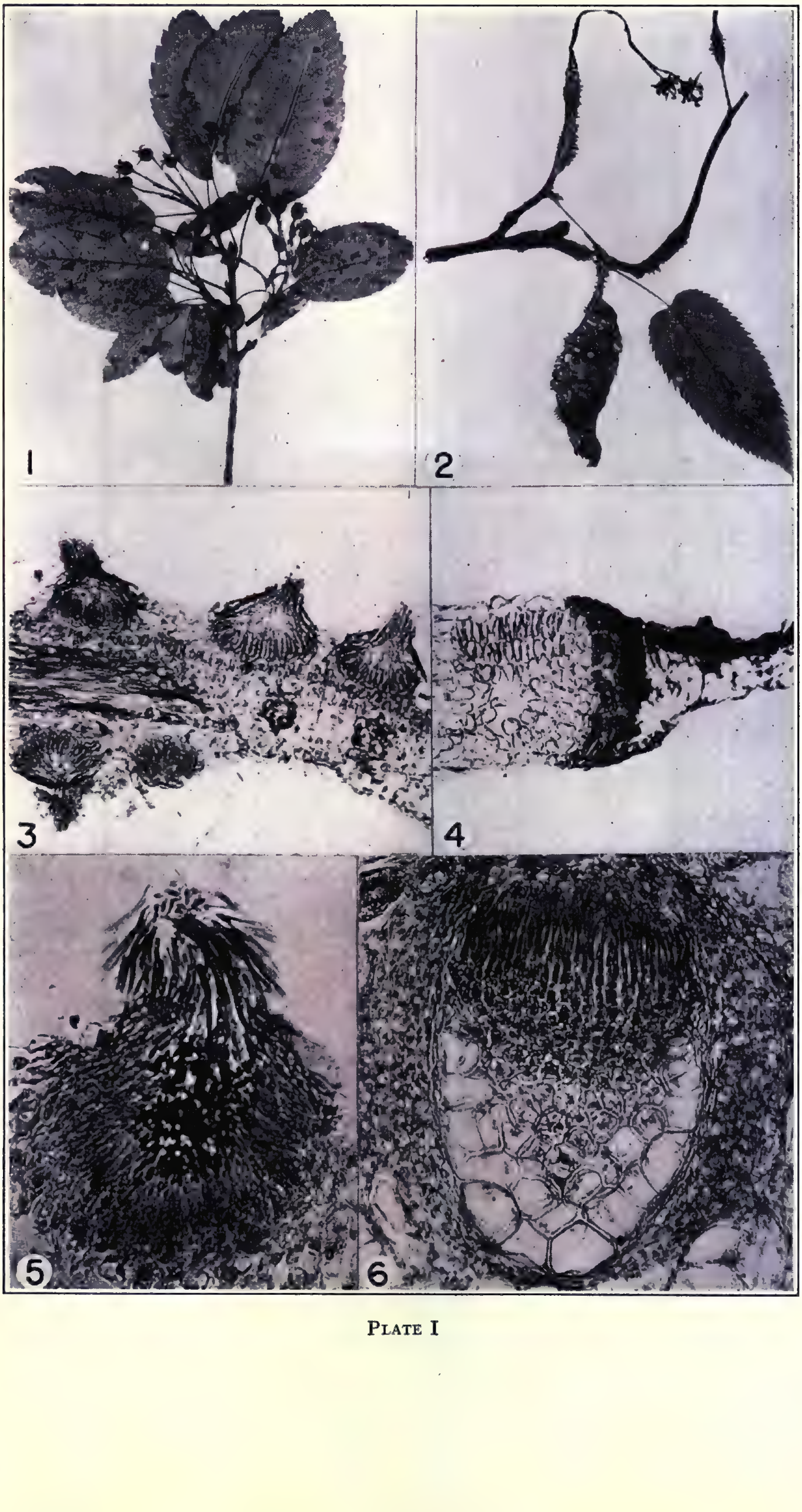


PLATE I

EXPLANATION OF PLATE II

Fig. 1. A dense broom caused by the telial stage of *G. nidus-avis* on *Juniperus virginiana* var. *crebra*.

Fig. 2. Foliicolous telia on leaves of *Juniperus horizontalis*.

Fig. 3. Caulicolous telia of *G. nidus-avis* on infected branch of *Juniperus virginiana*.

Fig. 4. A dense broom caused by the telial stage of *G. nidus-avis* on *Juniperus scopulorum*.

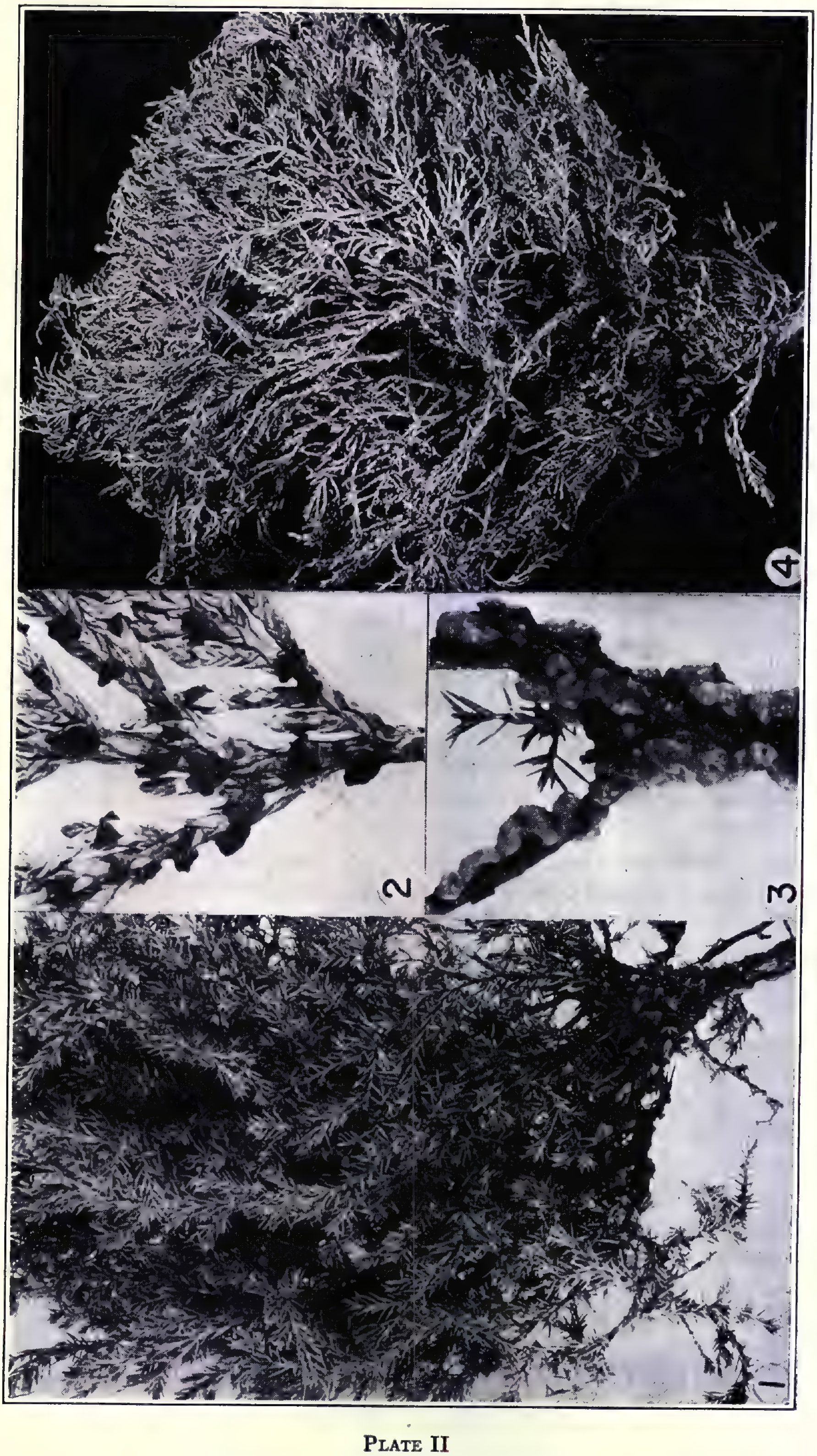


PLATE II

2(4):527–567 FARLOWIA JULY, 1946

THE BOLETINEAE OF FLORIDA WITH NOTES ON EXTRALIMITAL SPECIES

IV. THE LAMELLATE FAMILIES (GOMPHIDIACEAE PAXILLACEAE, and JUGASPORACEAE)

R. SINGER

As *Lenzites* is close to *Coriolus* in the Aphyllophorales, so, in the Boletineae, some lamellate families come closer to certain genera of the Boletaceae than other tubulose groups, *e.g. Paxillus* seems to be closer to *Gyrodon* than *Strobilomyces* or *Porphyrellus*. The relationship between *Paxillus* and the Boletaceae was actually recognized long ago, but the relationship between the Gomphidiaceae and the Boletineae had been doubted by some mycologists (including Gilbert), and it was necessary to draw attention to the similarities between these groups. (See Ann. Mycol. **40:** 555. 1942.) As for the Jugasporaceae, they seem to be intermediate, according to their characters, between the Boletineae and the Agaricineae (*Rhodophyllus*, Rhodogoniosporaceae; *Rhodocybe*, Tricholomataceae). For reasons we shall point out later (p. 548), we have always preferred to consider them as a family of the Boletineae.

The following monograph of the three families named above is written in the same pattern as the three preceding monographs on Florida Boletineae.[1] For a general introduction and a key to the families, the reader is again referred to Part I (Farlowia **2:** 97. 1945). In addition to the acknowledgments in my first monograph (*l.c.*), I wish to express my thanks to Dr. L. R. Hesler, University of Tennessee, and especially to Dr. A. H. Smith, University of Michigan, for the loan of important material of *Gomphidius* without which I would never have been able to prepare that genus for *North American Flora*, a manuscript on which the following treatment of the Gomphidiaceae of Florida is based.

GOMPHIDIACEAE R. Maire (1933)

Characters of the family: Pileus glabrous or tomentose or farinaceous, viscid to glutinose or more rarely dry, small to rather large; hymenophore lamellate, consisting of rather thick, decidedly decurrent gills with frequently obtuse edges (less so in subgenus *Chroogomphus*), waxy-subgelatinous to tender-fleshy consistency, and rather thick trama; lamellae subdistant to distant, more or less arcuate, gray to fuliginous when mature; spore print black; spores melleous to gray under the microscope, fusoid to subcylindric, smooth; cystidia large, projecting, usually distinctly incrusted, sometimes colored and with very thick walls (*Gomphidius to-*

[1] Singer, R. The Boletineae of Florida with notes on extralimital species. I. Farlowia **2**(1): 97–141. 1945; II. Farlowia **2**(2): 223–303. 1945; III. Amer. midl. nat. (in press).

mentosus), numerous to very rarely scattered (when old); trama of the gills more or less bilateral, not always clearly divergent, and very frequently partly interwoven, at least the hymenopodium interwoven but the trama never homogenously interwoven, nor intermixed, nor regular [2]); hyphae without clamp connections; stipe versiform, equal or swollen, etc., in most species and specimens with a discolored base which is pink or rich lemon yellow to orange yellow both inside and on the surface; veil present or absent, more often present, and then either entirely glutinous, or tender and fibrillose, or mealy and consisting of a loose pseudoparenchyma (*Cystogomphus*), sometimes forming an annulus; glandulae on the surface of the stipe present in one subgenus of *Gomphidius* (*Laricogomphus*); growing on earth and forming mycorrhiza with conifers, practically all species extratropical.

KEY TO THE GENERA AND THEIR SUBDIVISIONS

A. Veil consisting of spherocysts. Gen. *Cystogomphus*

A. Veil, if present, not consisting of spherocysts. Gen. *Gomphidius*

B. Context of the pileus ochraceous to orange (though at times in young specimens rather pallid), more rarely salmon to pink; veil constantly present, consisting of strictly parallel, pigment-incrusted hyphae, macroscopically never entirely glutinous, never hyaline; subhymenium filamentous-intermixed and dense to very dense; mediostratum rudimentary in young specimens, indiscernable in adult ones. Subgen. *Chroogomphus*

C. Pileus dry to subviscid in wet weather, not shining in dry weather, more or less tomentose to fibrillose. Sect. *Floccigomphus*

C. Pileus viscid in wet weather, shining in dry weather, not tomentose and not fibrillose except for traces of the veil on the margin. Sect. *Viscogomphus*

B. Context of the pileus white, more rarely pink to salmon, or becoming pink on exposure; veil absent, or consisting of subparallel-subinterwoven, thin hyphae which are not incrusted by pigment, macroscopically hyaline to white, and often entirely glutinous, sometimes blackening with age; subhymenium filamentous-cellular to filamentous, moderately dense; mediostratum of young specimens distinct, less distinct in older ones.

D. Veil visible only in the primordium, fugacious and not leaving any traces in adult specimens; dermatocystidia of the stipe fasciculate and the fascicles forming glandulae which make the stipe appear fibrillose or furfuraceous (though these macroscopical characters are not always easy to ascertain); mycelium (*of G. maculatus*) connected with *Larix*-mycorrhiza. Subgen. *Laricogomphus*

D. Veil covering the lamellae of the young specimens and leaving more or less distinct traces even in old specimens; dermatocystidia of the stipe not fasciculate, no fibrils or glandulae made up of dermatocystidia present on the surface of the stipe; mycelium in nature not connected with *Larix* but forming mycorrhiza with other conifers. Subgen. *Myxogomphus*

E. Spores (with the exception of immature and aborted ones) longer than 14 μ. Sect. *Macrosporus*

E. Spores, or majority of spores, shorter than 14 μ, or just reaching 14 μ. Sect. *Microsporus*

[2] See also observations for subgenus *Chroogomphus*, sect. *Viscogomphus*, p. 529.

Cystogomphus Sing., Ann. Mycol. **40:** 51. 1942.

Characters of the genus: these are evident in the key above. Type species *Cystogomphus Humblotii* Sing. No species is recorded in Florida.

Gomphidius Fr., Epicrisis, p. 319. 1938.

Characters of the genus: these are evident in the key above. Type species *Gomphidius glutinosus* (Schaeff. *ex*) Fr.

Subgen. **Chroogomphus** Sing., (in print).

Characters of the subgenus: these are evident in the key above. Type species *Gomphidius rutilus* (Schaeff. *ex* Fr.) Lundell & Nannf.

Sect. **Floccigomphus** Imai, Jour. Fac. Agr. Hokkaido Imp. Univ. **43:** 285. 1938.

Characters of the section: these are evident in the key above. Type species *Gomphidius tomentosus* Murr. Other species *G. sibiricus* Sing.; *G. leptocystis* Sing. In Florida none of these occurs.

Sect. **Viscogomphus** Imai, Jour. Fac. Agr. Hokkaido Imp. Univ. **43:** 284. 1938.

The characters of this section are obvious in the key above. The type species is the same as in subgenus *Chroogomphus*.

There have been various and seemingly controversial statements concerning the subhymenial and tramal structure of this section as compared with other sections. As for the trama, Fayod (1889) says it is bilateral quite generally in *Gomphidius*, and expresses surprise that De Seynes' figures do not show any bilateral trend. Lohwag (1937) finds the trama typically bilateral (truly bilateral as we call it in this paper) in *G. glutinosus*, and not distinctly bilateral, becoming irregular in *G. rutilus*. Elrod and Blanchard (1939) studied *G. maculatus* and found that the trama is "slightly and loosely interlaced, with a tendency toward a subparallel condition in many places. There is no sign of a differentiated mediostratum and laterostratum." In regard to the subhymenium the situation is still more obscure. Fayod (*l.c.*) says there is none. Lohwag (*l.c.*) and Singer (1942) state that there is one, and that it is pseudoparenchymatic in *G. rutilus*, and filamentous in *G. glutinosus*. Elrod and Blanchard (1939) and also Singer (1938) state that it is filamentous in *G. maculatus*. There is in all species, no doubt, a more or less definite layer immediately beneath the hymenium, but more recent re-examination by the writer tends to modify the above statements, and partly reverse them. It is true that in a not too thin section of the lamella of *G. vinicolor* the subhymenium appears to be coarsely cellular, but more detailed examination of the base of the hymenium shows a dense tissue of strongly interlaced, curved, irregular, strongly coherent hyphae which look cellular where they run for a short distance in a vertical direction. However, very few of the individual hyphae are short enough to be called subisodiametric and then they are very small, or very irregular, *e.g.* the widened hyphae from which two

branching hyphae arise, or the basal cells of the basidia. The subhymenium is not well differentiated from the underlying formation, and, in a sense, it may be stated that there is none. If we reserve the name subhymenium for a thin set of hyphae, continuing the basidia from their base downward, we cannot call it pseudoparenchymatic. *It is filamentous-intermixed.* As for the subhymenium of *G. glutinosus*, we may say that on superficial examination it always appears to be filamentous, but when the subhymenial cells are examined carefully and individually, they frequently turn out to consist partly of chains of very small globose bodies, and the same condition has been observed recently by the writer in *G. maculatus*.

The trama proper is not *a priori* different in *G. vinicolor*, *G. glutinosus*, *G. roseus*, and *G. maculatus* (the hymenophoral anatomy of *G. rutilus* does not differ from that of *G. vinicolor*). The difference pointed out by Lohwag and Peringer (1937) is not so striking, and more a matter of degree and of individual development. The mediostratum of *G. vinicolor* is very strongly reduced, so much so that no darker zone is seen in the pallid middle layer, called, as a whole, mediostratum by the above-cited authors. The irregular, interlaced accompanying zone between this and the subhymenium is called lateral stratum by all authors though I should think that it would rather deserve the name hymenopodium, since most of the looser central portion of the trama (Lohwag and Peringer's mediostratum) actually corresponds to the loose lateral stratum of the boletes. This will also make understandable the complicated tramal structure of *G. glutinosus*. In this latter species, we found a well-developed, melleous mediostratum, and there is no choice, in this case, but to call the hyaline looser layers at its sides the lateral stratum. The next-following layer between the lateral stratum and the subhymenium proper differs from the lateral stratum in being again more interlaced and dense. This layer is neither a part of the lateral stratum nor a part of the subhymenium. It is the hymenopodium. Lohwag and Peringer (*l.c.*) in the case of *G. glutinosus*, do not distinguish between this and the subhymenium proper, and, consequently, what they call subhymenium is the subhymenium plus the hymenopodium.

The gradual difference, therefore, between the trama of *G. glutinosus* and *G. vinicolor* (and *G. rutilus*) consists in the stronger or weaker development of the mediostratum proper on one hand, and the more or less decided tendency toward an irregular, interlaced condition in all or some layers on the other. It seems that other species may be intermediate between these extreme cases, for in my notes I described the trama of *G. roseus* exactly as it is in *G. glutinosus* though without mentioning the existence of a mediostratum, and as we saw above, Elrod and Blanchard did the same in the case of *G. maculatus*. However, it is obvious that the structure of the trama in the Gomphidiaceae, as in general in most Boletineae, is subject to drastic changes during the individual development of the carpophore, and our specimens may have been somewhat too old. Though the photographs published by Elrod and Blanchard do not show much as far

as the exact structure of the various layers goes, Lohwag and Peringer's figures 11–13 show this difference in different stages.

Another important fact not indicated in the literature on Gomphidiaceae, is the change in color of the spores when these are preserved in the herbarium for a considerable time. There is a specimen called *Gomphidius viscidus* [described here as *G. rutilus* (Schff.) Fr. ssp. *alabamensis*] collected ninety-five years ago and preserved in the Curtis Herbarium (FH) with a spore print on blue paper attached to it. The spores of the print are now ferruginous macroscopically, and greenish melleous under the microscope. This discoloration should be kept in mind when older herbarium material is described. I have never seen any of Fayod's specimens of *Gymnogomphus* Fay., but the description suggests that some old specimens of *G. rutilus* or of its group were misinterpreted and a new genus was created because of this fact.

KEY TO THE SPECIES

A. Mycelium pink-salmoneous; base of the stipe usually not markedly discolorous (yellow).

B. Middle portion of the cystidia strongly thick-walled, apex and base thin-walled. 1. *Gomphidius vinicolor* (in Florida: ssp. *jamaicensis*)

B. Middle portion of the cystidia not markedly thick-walled, wall of the cystidia nearly equal, thin to very slightly thickened (not more than 1.7 μ at most). *Gomphidius ochraceus*

A. Mycelium never pink-salmoneous, but pale yellowish white to "Isabella color"; base of the stipe frequently markedly discolorous, yellow. 2. *Gomphidius rutilus* (in Florida: ssp. *alabamensis*)

1. Gomphidius vinicolor Peck ssp. **jamaicensis** (Murr.) Sing. comb. nov.
Gomphidius jamaicensis Murr. Mycologia **10:** 69. 1918.
Gomphidius alachuanus Murr., Jour. Elisha Mitch. Sci. Soc. **55:** 367. 1939.

PLATE I, FIG. 4–7.

Pileus between "Natal brown" and "Army brown" with some tints of "light vinaceous cinnamon" to "Mikado brown" intermixed, or almost "chestnut," viscid, during dry periods "liver brown," "carob brown," or sometimes somewhat darker than these and shining, sometimes pallescent on the disk and becoming "Kaiser brown" or even "ferrugineous," glabrous, naked, smooth, conic-convex, then convex, eventually usually more or less flattened, or with depressed center, obtuse, (24)–50–(98) mm. diam. — *Hymenophore* between "Prout's brown" and "mummy brown," initially dirty ochraceous-alutaceous, eventually black from the spores, the lamellae broadest in the middle (4–10 mm.), subclose to subdistant, arcuate, decurrent, intermixed (one lamellula after either one or two through-lamellae), slightly transversely venose, only occasionally and very sparsely forked; spore print black. — *Stipe* "light vinaceous cinnamon" to "buff pink," or "vinaceous rufous," the base usually "cinnamon" to "clay color," "light ochraceous buff," or "ochraceous buff," sometimes at places becoming "Jasper red" or "orange cinnamon" to "cacao brown," not viscid, glabrous

except for the veil, smooth but more or less grooved when drying, naked, gradually tapering downward, or subequal, solid, 36–100 x 4–15 mm.; veil either forming a definite, fibrillose-woolly, narrow annulus which is concolorous with the remaining surface of the stipe, or reduced to a mere fibrillose zone at the apex of the stipe; mycelium pink. — *Context* of the pileus and upper portion of the stipe "pale ochraceous salmon" to "ochraceous salmon," or "pinkish buff" in pileus and "cinnamon buff" in upper part of stipe, in the base "primuline yellow" with a tinge of "yellow ocher" or "clay color," often somewhat umber immediately below the cuticle, fleshy, rather firm, not as soft and watery as in *G. glutinosus*; odor none, or agreeable when quite young, recalling apples or apple sauce; taste mild.

Spores melleous-grayish to gray, varying from a pure cinereous to fuliginous gray, ellipsoid to fusoid, not cylindric, smooth, (in carpophores with the spores of small average size, the short spores are usually the broadest, and the long ones the slenderest), 17–21.8 x 5.8–8μ; *basidia* (2)–4–spored, 34–46 x (8.2)–9.2–13μ; *cystidia* numerous, on edge as well as on sides of lamellae, slightly incrusted on the inside of the walls in many of them, the incrustation melleous, and in almost all of them there is a strong resinous or occasionally granular, fulvous-castaneous incrustation that covers the apices, otherwise smooth, thick-walled, the wall hyaline, thinner or quite thin at the apex which is frequently capitate, rarely clavate, and always broadly rounded, cylindric or slightly fusoid below, and there the walls reaching 2–5.5 μ in diameter but becoming thin near the very base, the entire length varying between 115 and 150 μ, the diameter from 13.5 to 22.5μ, the base reaching into the lateral stratum, the upper portion projecting well beyond the level of the sterigmata; *subhymenium* filamentous-intermixed; *trama* consisting of an indistinct mediostratum reduced to a central string of a few parallel or subinterwoven hyphae which are all hyaline and cylindric, but most of the trama proper (i.e. excluding the hymenopodium) formed by a hyaline, loosely arranged, partly subirregular layer that with age becomes homogeneous and increasingly irregular while any trace of a mediostratum disappears; *hymenopodium* obscured and thickly covered by an adhesive (sordid melleous brown) pigment that precipitates in form of an amorphous intercellular pigment when the preparation is boiled in 10% KOH, differing in this regard from the trama proper, and differing, also, in its much denser arrangement, the hyphae being more variable in diameter and running in all directions to form a subintermixed broad zone along the subhymenial layers; all *hyphae* without clamp connections; *pellicle* of repent, subparallel-interwoven, with fulvous-castaneous incrustation, elongate, clampless hyphae; *mycelium* consisting of filamentous hyphae which are beset with button-like ornamentations.

Chemical reactions: **KOH** on pileus, little reaction; on context, between "pale rosolane purple" and "thuilite pink," becoming "spinel red"; in base, "rich brown." — **NH_3**–vapors on context, "liseran purple" and "pale rosolane purple"; in base olive. — **NH_4OH** on pileus, little reaction; on

context between "pale rosolane purple" and "thuilite pink," becoming "spinel red"; in base brownish. — **H_2SO_4**, little reaction but the treated portions of the base becoming deep fulvous yellow when dried subsequently. —**$FeSO_4$** in all parts, "deep olive" to "dark olive."

Habitat: In woods, in Florida under *Pinus taeda*, possibly also *P. australis*, and *P. palustris*, but not observed in pure stands of any of the latter species; on sandy soil, gregarious, fruiting from November to January.

Distribution: North Florida and Alabama, also in the West Indies (Jamaica).

Material studied: **Fla.:** Alachua Co., Gainesville, *Murrill et al. F 10213, F 18431, F 20040* (all FLAS, *det.* Murrill); Planera Hammock near Gainesville, *Murrill et al. det. Murrill F 19517, F 20086* (FLAS) **type** of *G. alachuanus*, Newnan's Lake, East of Gainesville, *West & Murrill F 18402* (FLAS); my own collections compared with the type and partly from the type locality: *F 1657, F 1657a, F 1657b, F 1657c, F 1657d, F 1657e* (all FH). — **Ala.:** Lee Co. Auburn, Fall 1897, *F. S. Earle & C. F. Baker* (*G. viscidus*) (NY). — **Jamaica, W.I.:** Cinchona, in 5000 ft. elevation, *Earle* (*352*), **type** (NY).

This species is divided into several geographic races and mycoecotypes (in the sense of Singer, Sovietsk. Botan. **1940,** (5–6):262–269). The subtropical (*G. alachuanus*) and tropical-montane (*G. jamaicensis*) form, having subclose to subdistant lamellae and forming mycorrhiza with pines of the section *Australes*, should properly be called ssp. *jamaicensis* while the northern and western forms occurring with such pines as *Pinus resinosa*, and *P. radiata*, and differing morphologically in having more distant lamellae and frequently umbonate pileus, should be distinguished under separate subspecific names. The northern subspecies of *G. vinicolor* Murr. has the same characteristic cystidia with thick walls in the middle portion as has been observed in the southern form. It should not be confused with *G. ochraceus* Kauffm. and allied forms such as *G. superiorensis* Kauffm. & Sm., which also have pink mycelium and similar colors under certain conditions and in certain stages, but lack the thick cystidial walls. *G. tomentosus* Murr., which has thick-walled cystidia, has the walls nearly equally thick over the entire length of the cystidia, and not merely in the middle. *G. rutilus* and allied forms (ssp. *alabamensis*, the form called *G. furcatus* by Kauffman *non* Peck) is easily distinguished by the color of the mycelial tomentum and the thin-walled cystidia.

2. **Gomphidius rutilus** (Schaeff. *ex* Fr.) Lund. & Nannf., Fung. Exs. Suec. 409. 1937.
Agaricus rutilus Schaeff. ex Fr., Syst. Mycol. **1:** 315. 1821.
Cortinaria rutila S. F. Gray, Nat. Arr. Brit. Pl. **2:** 629. 1821.
Gomphidius viscidus (L. *ex*) Fr., Epicrisis, p. 319. 1838.
Paxillus pubescens Ellis, Bull. Torr. Bot. Cl. **6:** 76. 1876. (= ssp. *alabamensis*)
Gomphidius testaceus (Fr.) Britz., Hymen. Südbay. **4**: 133. 1885. (=var. *testaceus*)
Gomphidius litigiosus Britz., Hymen. Südbay. **9:** 14. 1893. (= var. *litigiosus*)
Gomphidius alabamensis Earle, Torreya **2:** 54. 1902. *nomen nudum* (= ssp. *alabamensis*)
Gomphidius viscidus forma *columbiana* Kauffm., Mycologia **17:** 122. 1925.

Ssp. **typicus.**

The type subspecies, the most common *Gomphidius* in Europe and in parts of the Rocky Mountain region, does not occur in Florida. It differs only slightly from the following subspecies (*alabamensis*) in having the pileus almost constantly umbonate, and in its geographic area.

Var. **testaceus** Fr., Epicr., p. 319. 1838 (*ut varietas G. viscidi*)

This is a small umbonate form with very light, almost white mycelium, and with the stipe lacking the yellow color of the surface and of the context. I have collected it under pines in mixed beech woods in Europe, but not in this country. Good typical specimens are preserved in the Hoehnel Herbarium (FH), from Tullnerbach-Pressbaum, Wiener Wald, Austria (*F. v. Höhnel B 1467*). The specimens described and illustrated under the name of *Gomphidius viscidus* var. *testaceus* Fr. in *Icones Farlowianae*, pl. 70, are a form of *G. ochraceus* Kauffm. *G. viscidus* fa. *testacea* Kavina seems to belong either to var. *pulcher* or var. *fulmineus*.

Var. **pulcher** Killerm. Denkschr. Bay. Bot. Ges. **21:** 58. 1940 (*ut varietas G. viscidi*)
Var. **litigiosus** (Britz.) Sing. comb. nov.

These two varieties, with differently colored pilei, are both described from Bavaria, not reported from America.

Var. **fulmineus** Heim, Treb. Mus. Ciènc. Nat. **15:** 68. pl. 1, *fig. 3.* 1934 (*ut varietas G. viscidi*)

This was described from Spain; it is possibly specifically different.

Kauffman described a f. *columbiana* which, as he thought, represents the American form of *G. viscidus* (*G. rutilus* ssp. *typicus* in our nomenclature). However, the examination of his herbarium shows that he mixed two different species under this name, one being an umbonate form of *G. ochraceus*, the other (including the type specimen) being *G. rutilus* ssp. *typicus*. It appears that Kauffman was under the impression that the European *G. rutilus* always is a large plant, which is definitely not true. Thus there remain only two differences between the European and the American form which escaped Kauffman. One is the frequently brighter color of the base of the American specimens, a character that aside from its vagueness does not seem to be quite constant. The other is a phytosociological character which could possibly be physiological: the American form is associated with pines of the series *Insignes* while the European form is associated with pines of the series *Lariciones*. If it could be demonstrated by experiments that the European form does not form mycorrhiza with *Pinus contorta* as readily as it does with *P. silvestris*, it would make the American form a mycoecotype lacking morphological differences (comparable with the races of rusts). However, as long as such physiological differences have not been shown, I prefer to list f. *columbiana* as a plain synonym of *G. rutilus* ssp. *typicus*.

Subsp. **alabamensis** (Earle *ex*) Sing. subsp. nov.

Gomphidius alabamensis Earle, Torreya **2:** 54. 1902 (*nomen subnudum*)
Paxillus pubescens Ellis, Bull. Torr. Bot. Cl. **6:** 76. 1876.

PLATE I, FIG. 1–3.

Tomento myceliali cremeo-albo vel melleo-isabellino; basi plerumque laete flavo in siccis; umbone plerumque nulla; cystidiis tenuitunicatis, incrustatis; ceterum *Gomphidio rutilo* et *G. vinicolori* analogus.

Pileus "light russet vinaceous," "cinnamon buff," "vinaceous cinnamon," "testaceous," sometimes reaching "chocolate," "Hay's brown" or "dark vinaceous brown," assuming at times colors like "pecan brown" or "purplish vinaceous" after drying, usually a lighter reddish-brown in dried specimens than *G. jamaicensis*, glabrous, more rarely with cracking pellicle showing orange flesh between the fragments, viscid, naked, shining when dry, convex to plane, eventually often depressed and turbinate, obtuse, rarely indistinctly umbonate, 30–100 mm. broad, mostly between 30 and 70 mm. — *Lamellae* "avellaneous," "clay color," "ochraceous tawny," later "testaceous," "snuff brown," or "sayal brown," and finally darker sooty from the spores, arcuate, then descendant, broad, subclose to distant, entire, thick, inserted with very short ones, occasionally some forked near the stipe, decurrent. Spore print "hair brown" to "deep grayish olive" in thin to moderate layer, very nearly black in good print. — *Stipe* varying from sordid whitish to "Congo pink" or subconcolorous with the veil which is "ochraceous buff" or "capucine buff," or streaked with vinaceous brown to almost tawny, with a bright yellow color very often at the very base of the dried stipes, mycelium cream-white to melleous-yellow or "Isabella color," strigose, the upper surface fibrillose and often showing a cortina-like annulus at the apex, glabrescent below, the veil often spurious, the outer fibrils somewhat slippery-sticky-subviscid in very wet weather but never gelatinous, inside solid, the shape equal with attenuate base, or fully equal and cylindric, or occasionally compressed, or tapering from the apex downward, straight or curved, 25–90 x 8–18–(40) mm. — *Context* of the pileus thick in the center, thin on margin, varying from almost white (though usually showing a slight brownish-orange tinge) to "buff pink," soft; of stipe "Congo pink" to subconcolorous with the pileus, the base mostly more or less yellow inside. *Odor* none to slight. *Taste* mild.

Spores (16)–18–21 x 5.8–6.5 μ, subcylindric-fusiform, smooth, melleous, grayish-melleous; *basidia* 4–spored, 40–55 x 11–12.8 μ; *cystidia* abundant, cylindric to cylindric-ventricose, or subcapitate, with narrowed base and rounded apex, incrusted or more rarely not incrusted, with or without granular contents, 95–150 x 12–18 μ, on sides and edges; *subhymenium*, *hymenopodium*, *lateral stratum*, and *mediostratum* as in *G. jamaicensis* (the subhymenium perhaps very slightly looser); *cuticle* of incrusted repent filamentous hyphae; *hyphae* without clamp connections.

Habitat: In mixed and pine woods under *Pinus* (species of the series *Insignes* and *Australes*), terrestrial, gregarious, fruiting from October to January.

Distribution: Maryland to South Carolina and west to Alabama and Tennessee, south to north Florida. In Florida rare, and observed only once in the western part of Alachua Co.

Material studied: **Fla.:** Near Seven-Mile-Church, 7 mi. west of Gainesville, January 8, 1940, *W. A. Murrill & J. R. Watson, det.* Murrill (*G. alachuanus*) (*ex* Herb. Erdman West, NY).—**N.J.:** Newfield, Oct. 10, 1887, on ground in pine woods, **Authentic** material of *P. pubescens* Ell. (NY).—**Md.:** South River near Annapolis, Oct. 6, 1919, *J. R. Morris, comm. H. A. Kelly (276), det.* L. C. C. Krieger (*Gomphidius spec.*) (MICH); Takoma Park, Oct. 12, 1918, *Kauffman* (*G. furcatus*).—**N. C.:** Chapel Hill, Oct. 1912, *W. B. Cobb 582* (NY).—**S. C.:** Society Hill, *Curtis 2855* (FH).—**Tenn.:** Ball Camp Pike, Nov. 1937, *Hesler & Sharp 10986, det.* A. H. Smith (*G. viscidus*) (MICH); Dec. 25, 1941, *L. R. Hesler* (*G. viscidus* f. *columbiana*) *14120* (MICH); near Clinton, Nov. 11, 1934, *L. R. Hesler 7792, det.* A. H. Smith (*G. vinicolor*) (FH, MICH).—**Ala.: type** of *G. alabamensis*, Auburn, Dec. 1900, *E. S. & F. S. Earle* (*2845*) (NY).

Earle published *G. alabamensis* in a key to the species of *Gomphidius*, but without a formal description. The characters given in the key do not determine the species as such, but notes with some of his specimens which he called *G. viscidus*, and the specimen which we consider the type of *G. alabamensis*, do not leave any doubt as to what Earle had in mind when he used the binomial *Gomphidius alabamensis*. The specimens of *G. furcatus* Peck, however, belong rather to *G. maculatus* than to this form, and we think, therefore, that Kauffman was wrong in identifying *G. alabamensis* with *G. furcatus*.

EXTRALIMITAL SPECIES

Gomphidius ochraceus Kauffm., Mycologia **17**(3): 119. 1925.

Gomphidius superiorensis Kauffm. & Smith, Papers Mich. Acad. Sci. Arts & Lett. **17:** 170. 1933. (a variety)

A polymorphous species, close to *G. rutilus*, not occurring in Florida.

Subgen. **Laricogomphus** Sing., (in press)

Characters of the subgenus: these are evident from the data in the key. Type species *G. maculatus* (Scop. *ex* Fr.) Fr. Not occurring in Florida.

Subgen. **Myxogomphus** Sing., (in press)

Characters of the subgenus: these are evident from the key. Type species *G. glutinosus* (Schaeff. *ex* Fr.) Fr.

Sect. **Macrosporus** Sing., (in press)

Characters of the section: these are evident from the key. Type species *G. glutinosus* (Schaeff. *ex* Fr.) Fr. This and the other species of this section, *viz. G. septentrionalis* Sing., *G. nigricans* Peck, *G. Smithii* Sing.,

G. subroseus Kauffm., *G. roseus* (Fr.) Karst. do not occur as far south as Florida.

Sect. **Microsporus** Sing., (in press)

Characters of the section: see key. Type species *G. oregonensis* Peck, a western species. Another species may occur in Europe, none in Florida.

SPECIES EXCLUDENDAE

Gomphidius foliiporus Murr.

This is *Phylloporus rhodoxanthus* ssp. *foliiporus* (Murr.) Sing.

Gomphidius rhodoxanthus (Schwein.) Sacc.

This is the American type of *Phylloporus rhodoxanthus* (Schw.) Bres.

PAXILLACEAE R. Maire (1902)

Characters of the family: pileus subtomentose to tomentose, sometimes viscid, small to large, the margin initially inrolled; hymenophore lamellose, but the lamellae very frequently connected by anastomosing veins and ridges, or the sides of the lamellae venose-rugose, more rarely the anastomoses broad and numerous and then the hymenophore resembles that of *Merulius*, arcuate, usually rather narrow, yellow, orange, or light tan to brown; spore print from nearly white to chamois or brownish; spores rather small to medium (3–11.5 μ long), smooth, ovoid, subglobose, ellipsoid or oblong-ellipsoid; cystidia present or absent; trama more or less bilateral; hyphae constantly with clamp connections; stipe very frequently eccentric to lateral or wanting; veil, said to be present in *Paxillus argentinus*, mostly none. Habitat: on earth or on wood, or on sawdust, rarer in the tropics but not entirely confined to extratropical regions, not forming mycorrhiza with specific flowering plants.

The Paxillaceae are closely related to the Boletaceae, especially the genus *Gyrodon*. Aside from the more individualized lamellae (even if they are connected by anastomoses), the more involute margin of young specimens, and the biological differences (*Gyrodon* and most of the Boletaceae being mycorrhizal fungi while the Paxillaceae do not seem to be dependent on symbiosis with specific forest trees, which does not mean that they will never and under no circumstances whatever form anything comparable with mycorrhiza-relationship), there are some minor differences that separate this family from *Gyrodon*. There is, for example, a slight but distinct difference in the chemical reactions (see the descriptions of the species). The greenish-yellow color of the hymenophores in *Gyrodon* is indicative of its close relationship with the Boletaceae. There is also the occurrence, in some species of *Gyrodon*, of autoxidation causing a blue discoloration of the hymenophore and the flesh. This latter reaction is, although not a constant feature of all *Gyrodon*, a character common to

many groups of the Boletaceae, while in the Paxillaceae this blue discoloration is constantly absent. There also appears to be some difference between the structure of the tube walls of *Gyrodon* and the trama of the lamellae in *Paxillus*. In the former, the mediostratum is somewhat denser and somewhat colored while the lateral stratum is distinctly divergent and hyaline in young material. In *Paxillus*, we found the lateral stratum of our sections definitely strongly interwoven, not clearly diverging, and of a rather different aspect when compared with the lateral stratum of the *Gyrodon* spp. — so different, indeed, that it is possible to consider it as non-homologous with the lateral stratum of the Boletaceae. Instead, the homology is with the hymenopodium of the Gomphidiaceae (see p. 529), which, however, may be difficult to prove, since the middle layer is always homogenous. In this family, as well as in the Gomphidiaceae, the structure of the hymenophore trama changes strongly while the carpophores mature.

I cannot see any good reason for splitting the genus *Paxillus* into several genera, merely on the, for the most part imaginary, differences in tramal structure. These species are otherwise so similar, exactly as the *Gomphidii*, that there is no doubt about their close natural affinities. This is confirmed by the chemical reactions registered by the author. One has only to compare the reactions of *Paxillus involutus* (see Ann. Myc. **40:** 58. 1942) with these of *P. panuoides* (see this paper, p. 542). *Crepidotus*, which has been compared with *Paxillus panuoides*, belongs in an entirely different sphere of affinities, being very close to *Ripartites* (which also has been considered as belonging to *Paxillus* by Quélet, Ricken, and others), and some other genera. *Phylloporus* is too close to certain Boletaceae, especially *Xerocomus*, to be retained in the Paxillaceae.

The Paxillaceae and the Gomphidiaceae are no doubt related, as may be expected of two lamellae-bearing families within the suborder Boletineae. Their tramal structure has some analogies. But biologically, in spore color, spore size, in chemical characters, and, most important, in clamp connections, they are consistently different. In many ways the Gomphidiaceae are comparable with the Strobilomycetaceae, and the Paxillaceae with the Boletaceae.

KEY TO THE GENERA, SECTIONS, AND SPECIES KNOWN TO THE AUTHOR

A. Spore print at least "chamois" (Ridgway), or somewhat deeper brownish; lamellae more or less anastomosing, at least in some portions of the hymenophore. Gen. *Paxillus*

B. Spores up to 7.5 μ large; cystidia none.

C. Stipe present, large, tomentose. Sect. *Atrotomentosi*

D. Trama of the lamellae lilac, in NH_4OH blue. *Paxillus polychrous*

D. Trama of the lamellae not as above. *Paxillus atrotomentosus*

C. Stipe present, and then lateral and short, or absent. Sect. *Panuoides*

E. Spores 3.8–6 x 3–4.5 μ. Odor none or not remarkable.
3. *Paxillus panuoides*

E. Spores 3–4 x 1.7–2 μ. Odor sometimes persistent, disagreeable.
Paxillus Curtisii

B. Most spores more than 7.5 μ long; cystidia present.
Sect. *Involuti*
Paxillus involutus

A. Spore print almost white (somewhat cream colored in thick layer); lamellae not or little anastomosing (though strongly forked), not venose on their sides.
Gen. *Hygrophoropsis*

F. Spores 4.8–8 x 2.7–4.8 μ; basidia 19–40 x 5–9.5 μ; pileus 35–85 mm. in diameter; stipe central or somewhat eccentric, very rarely strongly eccentric to lateral; habitat in coniferous woods or in mixed woods under conifers, on moss beds, or on coniferous wood, or on naked earth.
5. *Hygrophoropsis aurantiaca*

F. Spores 3.3–4.8 x 2.5–3.3 μ; basidia 16–20 x 3.7–6.8 μ; pileus up to 31 mm. in diameter; stipe strongly eccentric, lateral, or entirely wanting; habitat on sawdust, in hollow trunks (*e.g.* of *Nyssa silvatica*) but not on coniferous trunks, also occurring on old frondose logs in dense hammocks.
4. *Hygrophoropsis tapinia*

Paxillus Fr., Gen. Hymen., p. 8. 1836.
Ruthea Opat., Comm. Bol., Wiegm. Arch. **2:** 4. 1836.
Tapinia Karst., Hattsv., p. XXIII. 1879.
Tapinella Gilbert, Bolets, p. 67. 1931.
Rhymovis Rabenh., Kryptogamenfl. **1:** 453. 1844.
Paxillopsis Gilbert, Bolets, p. 86. 1931 (*nom. nud.*), *non* Lange, Fl. Agar. Dan. **4:** 47. 1939.
Plicaturella Murr., N. Amer. Flor. **9:** 172. 1910 (*sec.* Murrill).

Characters of the genus: these are evident in the key above. Type species, *P. involutus* (Batsch *ex* Fr.) Fr. The only species thus far observed in Florida is *P. panuoides*.

The nomenclatorial problem in the case of the genus *Paxillus* is a rather simple one. The genus *Paxillus* and the genus *Ruthea*, based on the same plants, were both proposed in 1836, and it certainly was a good idea to put *Paxillus* on the list of *nomina generica conservanda* as proposed by R. Maire to be accepted by the next Botanical Congress, since it may turn out that Opatowski's little-known name has a few days' priority over the generally accepted name *Paxillus*. Unfortunately, Gilbert's chapter about this family has caused many wrong citations and erroneous conceptions due to some inaccuracies in his book "Les Bolets." In his chapter on the "Histoire Taxonomique du Genre Paxillus" (p. 64–69), he says: "Persoon . . . a explicitement créé le genre *Rhymovis* sur le *P. involutus*, pour les seules espèces étroitement affines aux Bolets. Quoique puisse en dire Fries . . . , ce genre *Rhymovis* a la priorité. . . . Il est bien curieux de constater que Earle (1909) et Murrill ne l'aient pas reprise." Persoon, however, did not validly describe a genus *Rhymovis* though he may have had the intention of doing so in the future. "Si plures species," he

says (Mycologia Europaea **3:** 63), "inveniuntur, huic [*i.e. Agaricus involutus*] conformes, tunc ex iis genus distinctum efformari posset, *Rhymovis* [3] forte denominandum." It is inconceivable that anyone who has read this could possibly consider *Rhymoxis* as a published genus. It must be assumed that Earle and Murrill *did* read what Persoon said. They, therefore, knew that *Rhymovis* was not published before 1844 by Rabenhorst, *i.e.* eight years after Fries published *Paxillus*. Gilbert continues: "Berkeley (1836) crée lui aussi, sur *P. involutus*, un genre *Tapinia* qui sera repris comme sous-genre par Fries (1838) . . . Karsten (1879) . . . démembrait ce *Paxillus* (= *Tapinia*): *Paxillus* pour le *P. involutus* et ses affines, et *Tapinia* pour le *T. panuoides*. . . . Il est donc nécessaire de rejeter le terme générique *Tapinia*, d'ailleurs illégalement employé." If we check on Gilbert's "Histoire" again, it turns out that Berkeley in 1836 did not use *Tapinia* as a genus but as a subgenus. Karsten's *Tapinia*, therefore, is legal, though in my opinion not worthy of generic distinction. This whole situation was clear enough in the synonymy given in North American Flora **10**(3) : 146–147. 1917, and did not need to be "embrouillé" as late as 1931.

Sect. **Atrotomentosi** Sing. sect. nov.

Stipite praesente, vellereo; sporis parvulis; cystidiis nullis.

Characters of the section evident from the key above and the Latin diagnosis. Type species *P. atrotomentosus* (Batsch *ex* Fr.) Fr. Other species *P. polychrous* Sing. None of them found in Florida.

P. atrotomentosus is a well-known species, frequent in North America but not reaching Florida. Specimens from New Hampshire show the following chemical reactions, recorded here for comparison with *P. panuoides*. **NH_4OH** on the surface of the pileus coloring the tomentum and the pallid surface of the context, "dull lavender" to "slate purple" but leaving the cuticle proper unchanged brown in most cases (at least in old specimens); "dull lavender" to "slate purple" on the context of the pileus and the stipe but changing more slowly than on the surface of the pileus. — **KOH** on the surface of the pileus, a dark spot with a violet to lilac ring; on the context of the stipe, greenish; on the tomentum of the stipe, blackish. — **H_2SO_4** on the surface of the pileus where previously treated with KOH or NH_4OH becoming "yellow ocher," then "Buckthorn brown" in a few seconds, changing more slowly and more indistinctly at places where not previously treated with KOH or NH_4OH. — **$FeSO_4$** darker brown, and eventually greenish black on the pileus, and dull greenish gray on the context of the stipe, eventually blackish.

Sect. **Panuoides** Sing. sect. nov.

Pileo subsessili.

[3] "*Rhymovis*" was a printing error, and was corrected to *Rhymoxis* by Persoon in the Errata corrigenda of his *Mycologia Europaea*, v. 3, a fact which escaped Rabenhorst who is the only one who used Persoon's name.

Characters of the section evident from the key above and the Latin diagnosis. Type species *P. panuoides* (Fr. *ex* Fr.) Fr., the only species known in Florida. Another species is *P. Curtisii* Berk. *apud*. B. & C.

3. **Paxillus panuoides** (Fr. *ex* Fr.) Fr., Epicrisis, p. 318. 1938.

Agaricus panuoides Fr. *ex* Fr., Syst. Mycol. **1**:273. 1821.
Agaricus lamellirugis D. C. *ex* Secr., Mycogr. Suisse **2:** 457. 1833.
Agaricus croceolamellatus Let., Ann. Sci. Nat. sér. II. **3:** 94. 1835.
Cantharellus Dutrochetii Turpin *apud* Mont., Ann. Sci. Nat., sér. II, **5:** 342. 1836.
Rhymovis panuoides Rabenh., Kryptogamenfl. **1:** 453. 1844.
Paxillus rudis Berk. & Curt., Ann. Mag. Nat. Hist. ser. III. **4:** 296. 1859.
Paxillus ligneus Berk. & Curt., Jour. Linn. Soc. **9:** 423. 1867.
Crepidotus croceolamellatus Gill., Champ. Fr. Hym., p. 557. 1878.
Tapinia panuoides Karst., Hattsv., p. 452. 1879.
Paxillus acheruntius (Humb. *ex*) Schröter, Jahresb. Schles. Ges. für 1884, p. 300. 1885.
Paxillus lamellirugus Quél., Enchir., p. 93. 1886.
Paxillus ionipus Quél., Assoc. Fr. Avanc. Sci., Congrès d. Toulouse, p. 588. 1887.
Tapinia lamellosa (Sow. *ex*) Murr., N. Amer. Fl. **10**(3): 146. 1917.
Tapinella panuoides Gilbert, Bolets, p. 67. 1931.
?*Gomphus pezizoides* Pers., Mycol. Europ. **2:** 10. 1825.
?*Cantharellus olivaceus* Schw., Trans. Amer. Phil. Soc. ser. II. **4:** 296. 1832 (*sec.* Murrill).

Pileus dusky ochraceous to olive ochraceous, "cartridge buff," "cream buff," "chamois," "honey yellow," "Isabella color," "colonial buff," "deep colonial buff," sometimes the basal tomentum purplish-violet, the entire surface pubescent to more or less tomentose but usually glabrescent, sometimes rivulose, conchoid, or spathulate-substipitate, dimidiate or with a short, indistinct, concolorous, lateral stipe, 20–85–(100) mm. — *Hymenophore* concolorous or, especially when young and fresh, more yellow, reaching a color between "Naples yellow" and "mustard yellow," eventually more dirty tan, or "chamois" from the spore dust, easily separable from the context, lamellae decurrent or radiating from an eccentric point, rather narrow or narrow, crisp, anastomosing by veins, at least near the base of the pileus, and sometimes strongly anastomosing-lamellose and corrugate because of veins which transversely run down the sides of the lamellae, occasionally some forked without forming anastomoses, rather close to close; spore print "chamois." — *Context* cream color to whitish, soft, rather thin to thin, but sometimes gradually thickening to rather thick near the point of attachment; taste mild or very slightly bitterish; odor none, or not remarkable.

Spores 3.8–6 x 3–4.5 μ, mostly around 4.8 x 3.5 μ in America, 5.8 x 3.5 μ in Europe, melleous-pallid or pale melleous, smooth, thin-walled, ovoid-ellipsoid; *basidia* 19–26 x 4.5–6.2 μ; *cystidia* and *cheilocystidia* none; *trama* of the lamellae bilateral, the mediostratum and the lateral stratum equally dense or the former denser, especially farther away from the edge, splitting along the mediostratum on increase of pressure; mediostratum composed of subparallel-subinterwoven hyphae in young stages and near

the edges, of more truly interwoven hyphae in age and near the ground of the lamellae, but always with a distinct axillar orientation; lateral stratum mainly directed obliquely toward the subhymenium but increasingly interwoven, irregular, and even intermixed with age because of the presence of broad, sometimes clavate hyphae near the subhymenium; *cilia* of the marginal tomentum of the pileus formed by 4–5 μ thick, long hyphae; *hyphae* with clamp connections.

Chemical reactions: **KOH** on the surface of the pileus, olive; on lamellae and context, olive to dull deep yellow; **NH_3**–vapors on the surface of the pileus, strongly lilaceous-drab, livid; **H_2SO_4** on the surface of the pileus, dull, deep yellow, little reaction elsewhere; **$FeSO_4$** on context slightly olive.

Habitat: On coniferous wood, on trunks and stumps in the forests as well as on structural wood in houses, on bridges, in mines, etc. where it is apt to develop fertile though mostly resupinate fruiting bodies in perfect darkness; preferring pine. Fruiting in summer to late fall if growing in the open in the northern states, elsewhere also found fruiting in winter and spring. Usually gregarious, frequently cespitose.

Distribution: Nearly a cosmopolite, but rarer or partly absent in the tropics. Known from North, Central and South America, Europe, Asia, Africa, and Australia. In Florida not common.

Material studied: **Fla.:** Alachua Co., Cary Forest, Nov. 1938, *Erdman West & W. A. Murrill, det.* Murrill, *F 17708* (FLAS).—**N. H.:** August 1860, *Blake, det.* Curtis *740* (FH).—**Mass.:** Harvard, on coniferous wood, July 1944, *Harrie Dadmun & R. Singer* (*det.* R. Singer) (FH); *Murray, Sprague* (*581*) (FH); type of *P. ligneus* B. & C. *Murray, Sprague* (*1149*) (FH); Floating Bridge, Lynn, August 1913, *E. B. Blackford* (FH); Arlington, Oct. 1907, *Piguet, det.* Farlow (FH).—**Conn.:** type of *P. hirtus* B. & C., *Wright 234* (FH).—**N. Y.:** Enfield Gorge, Sept. 1903, *C. H. Kauffman* (FH).—**S. C.:** Santee Canal, *Ravenel* (*1038*) (FH).—**Ga.:** NortheastGa. near Tallulah Falls, Tannery Brook, August 1901, *A. B. Seymour, det.* Farlow (FH).—**Tenn.:** Great Smoky Mts., Greenbrier, July 1939, *L. R. Hesler* (FH); Grassy Patch, July 1940, *A. J. Sharp, det.* L. R. Hesler (FH).—**Ala.:** "Alabama superioris" Dec. 1855, *Peters* (*925*) (FH).—**Ore.:** Wygand State Park, Hood River Co. Oct. 1937, *W. B. Cooke* (*9675*).—**Cal.:** Berkeley, February 1933 (FH).—**Mexico:** *Botteri, det.* Curtis (as *P. ligneus*) (2) (FH).—**Brazil:** São Leopoldo, 1932, *Rick* (FH).—**Sweden:** Upsala, 1853, *E. P. Fries* (FH).—**U.S.S.R.** (former Finland): Kellomäki, Sept. 1940, *R. Singer 5–789* (LE).

The European plant usually has slightly larger spores, but this character is by no means constant. Excellent colored figures of this have been published, best of all is that in Lange, Flor. Agar. Dan. **4:** pl. 134, *fig. B.* Elrod and Blanchard's photomicrograph (Mycologia **31:** 697. *fig. 1, D.* 1939) of the gill trama gives an idea of the structure of a not quite young though not very old specimen, but few details are visible. Josserand (Bull. Soc. Myc. Fr. **48**(2):112. *pl. 13, fig. 3.* 1932) published a better figure, showing exactly what we have seen and described above.

EXTRALIMITAL SPECIES

Paxillus Curtisii Berk. *apud* Berk. & Curt., Ann. Mag. Nat. Hist. ser. II. **12:** 423. 1853.

Paxillus corrugatus Atk., Stud. Amer. Fung., p. 170. 1900.

This species has smaller spores than *P. panuoides*, as is shown by examination of the type (on pine wood in Georgia), collected by Ravenel in September 1848, # 853, preserved at the Farlow Herbarium. In fact these spores are the smallest known in the Boletineae. Since this species occurs from New England to Georgia, it is possible that it will be discovered in north Florida.

Sect. **Involuti** Sing. sect. nov.

Pileo lateraliter vel excentrice vel subcentraliter stipitato; stipite glabro; sporis volumine mediocri gaudentibus; cystidiis praesentibus.

Characters of the section: see the key p. 539, and the above Latin diagnosis.

Paxillus involutus (Batsch *ex* Fr.) Fr. Epicrisis, p. 317. 1838.

This common and widely distributed species is remarkable for its absence in Florida. It occurs in Uruguay where it has been collected by Herter, determined as *Paxillus argentinus*, which strongly differs in having a veil. The trama of these specimens is divided into an intermixed-interwoven hymenopodium, and a subregular mediostratum or rather trama proper, consisting of brownish, 3.5–9 μ broad hyphae, while in the hymenopodium the hyphae are hyaline to brownish and still more variable in diameter; all hyphae with clamp connections; spores 8–11.5–(13) x 5–7.5 μ, the wall occasionally up to 1 μ thick; basidia 4-spored, about 31 x 7.8–9.8 μ; cystidia hyaline to brownish, versiform, 34–65 x 13–20 μ; hyphae of the cuticular layer of the pileus repent, long-cylindric. For the chemical reactions of European specimens, see Ann. Myc. **40:** 58. 1942.

SPECIES EXCLUDENDAE

Paxillus miniatus Rick, Broteria **5:** 19. 1906.

The type of this species does not exist in Brazil; authentic material kindly sent by J. Rick does not fit in the original diagnosis, and is a species of the Lentineae with smooth, hyaline spores. We therefore consider *P. miniatus* as a dubious species, and propose *P. russuloides* Petch as the type species of the genus *Phyllobolites* Sing. *P. lateritius* is also thought to belong in *Phyllobolites*.

Paxillus pubescens Ellis, see under *Gomphidius rutilus* ssp. *alabamensis*.

Paxillus pinguis Hook. fil. *apud* Berk., Hook. Journ. Bot. **3:** 41. 1851.

This is, as is shown by the unpublished colored figure of Hooker (FH), one of the subspecies of *Phylloporus rhodoxanthus*, and so are certainly *Paxillus flavidus* Berk., Lond. Journ. Bot. **6:** 315. 1847, *Paxillus rhodoxanthus* (Schw.) Ricken, Blätterpilze. **1:** 95. 1911, *Paxillus Tammii* Pat., Tab. Anal. **4:** 161. 1885, *Paxillus Pelletieri* (Lév.) Velen., Česk. Houb., p. 356. 1920, and *Paxillus paradoxus* (Kalchbr.) Cooke, Grevillea **5:** 6. 1876. *Paxillus sulphureus* Berk. is most probably another species of *Phylloporus*.

Paxillus prunulus (Scop. *ex* Fr.) Quél., Enchir., p. 92. 1886.

See *Clitopilus prunulus* Jugasporaceae, p. 551 of this paper.

Paxillus reniformis Berk. & Rav. *apud* Berk. & Curt., Ann. Mag. Nat. Hist. ser. II. **12:** 424. 1853.

This species described from North Carolina has been compared with *Paxillus panuoides* by Murrill, N. Amer. Fl. **10**(3): 146. 1917. However, the type (FH) has verrucosely punctate spores of 8.3–10.2 x 5.5–6.5 μ, and all the main characters of a *Crepidotus*. The combination **Crepidotus reniformis** (B. & R.) Sing. comb. nov. is proposed. *C. versutus* Peck is probably the same species.

Hygrophoropsis R. Maire *apud* Martin-Sans, L'Empoisonnement, p. 99. 1929.

Cantharellus subgen. *Hygrophoropsis* Schröter in Cohn, Krypt. Fl. Schles. **3**(1): 511. 1889.

Merulius S.F. Gray, Nat. Arr. Brit. Pl. **1:** 636. 1821 (*non* Fries).

Characters of the genus: see key, p. 539. Type species, *Hygrophoropsis aurantiaca* (Wulf. *ex* Fr.) Maire *apud* Martin-Sans [*Cantharellus aurantiacus* (Wulf.) *ex* Fr.]

The species entering this genus were formerly considered to belong in *Cantharellus*, but since they are fundamentally different in many regards from the type species of that genus, they were transferred by Studer, Maire, and others to *Clitocybe*. The writer formerly agreed with this point of view though *Hygrophoropsis* did not show close relationship with any group of *Clitocybe*. It appears that the characters in common with *Paxillus* are much more striking than the ones that suggested the comparison of *Hygrophoropsis* with *Clitocybe*. The soft context is typical for the Boletineae, and the tramal structure is strongly reminiscent of *Paxillus* and *Clitopilus*. The small, slightly yellowish spores are similar to these of *Paxillus panuoides*. The discovery of a second species, *H. tapinia*, with smaller spores and an external appearance frankly suggesting *Paxillus Curtisii* but never met with in *Clitocybe*, makes the affinity between *Hygrophoropsis* and *Paxillus* an established fact.

4. **Hygrophoropsis tapinia** Sing. spec. nov.

Pileo pallide aurantiaco, admodum excentrico vel astipitato, tomentoso, infundibuliformi-irregulari, carnoso atque tenui, usque ad 35 mm. lato; lamellis aurantiacis,

immutabilibus, furcatis, haud anastomosantibus nec corrugatis, acie obtusa instructis, angustis, descendentibus vel arcuate distincte profundeque decurrentibus; sporis in cumulo albidis, sub microscopio hyalinis vel pallide luteolis, 3.3–4.8 x 2.5–3.3 μ; basidiis 16–20 x 3.7–6.8 μ; cystidiis nullis; hyphis fibuligeris; stipite pumilo vel nullo, concolori; carne pallidiore, immutabili, molli, inodora. Habitatio: In truncis cavis, ad sarmenta in dumetis, etc., Septembri et Octobri mensibus, Florida, U.S.A.

Pileus "pale orange yellow," very eccentric to astipitate, tomentose, infundibuliform or irregular, fleshy but rather thin, up to 35 mm. broad. — *Hymenophore* "capucine orange," becoming brownish orange, unchanging on drying and on injury, strongly forking but not anastomosing nor corrugate, smooth with blunt edges, narrow, decurrent; spore print white or whitish on white paper in thin layer. — *Stipe* small, concolorous, or wanting. — *Context* paler than the surface, unchanging, soft, inodorous.

Spores hyaline to pale yellow under the microscope, 3.3–4.8 x 2.5–3.3 μ; *basidia* mostly 4–spored, 16–20 x 3.7–6.8 μ; *sterile bodies* in the hymenium not infrequent (aborted basidia?), extremely variable in shape, usually numerous on edge; typical *cystidia* absent; *trama* consisting of hyaline, thick (0.7μ) or thin-walled, often slightly gelatinized hyphae, bilateral with more parallel-subinterwoven hyphae in the axillarly arranged mediostratum (respectively trama proper), and with more irregularly arranged but mostly straight hyphae in the accompanying layers (lateral stratum or hymenopodium); *clamp connections* numerous.

Habitat: On dead trunks of frondose trees and on sawdust in dense hammocks, never under or on conifers. September and October.

Distribution: South Florida.

Material studied: **Fla.:** Dade Co., Simpson Park, Miami, on sawdust in dense tropical hammock vegetation, October 1942, *R. Singer F 1037* (FH); Brickell's Hammock, Miami, on a dead trunk in tropical hammock, October 1942, *R. Singer, F 1273* (FH).

This species is very close to *Hygrophoropsis aurantiaca* from which it is distinguished mainly by the smaller spores and the habit of fruiting which suggest *Paxillus Curtisii*. The description of a British species, *Paxillus Fagi*, may suggest to some our Florida species, but it is too poorly characterized and moreover the surface is said to be pallid. *Paxillus aurantiacus* Ellis probably belongs in this group but it reminds one rather of *Hygrophoropsis aurantiaca* than of *H. tapinia*.

5. **Hygrophoropsis aurantiaca** (Wulfen *ex* Fr.) R. Maire *apud* Martin-Sans, L'Empoisonnement p. 99. 1929.

Cantharellus aurantiacus Fr., Syst. Myc. **1:** 318. 1821.
Merulius aurantiacus Persoon *ex* S. F. Gray, Nat. Arr. Brit. Pl. **1:** 636. 1821.
Cantharellus Ravenelii Berk. & Curt., Ann. Mag. Nat. Hist. ser. II. **12:** 425. 1853.
Clitocybe aurantiaca Studer, Beiblatt z. Hedwigia **39:**(7). 1900.
Chanterel alectorolophoides (Schaeff. *ex*) Murrill, N. Amer. Flora **9**(3): 169. 1910.

Var. **typica**

The type variety is a common species in the northern states of this country, in Canada, in Europe, especially in the northern and central part of that continent, and in Asia. I have collected typical specimens in all these regions but not farther south than the Caucasus Mts. in Asia. D. H. Linder has collected good specimens in Virginia, U.S.A., as did L. R. Hesler in Tennessee, and Ravenel collected the type of *Cantharellus Ravenelii* B. & C. in South Carolina. This is definitely the most southerly place where this species has been found in this hemisphere. The type is in rather good condition, and appears to belong here, as suggested by Murrill. The spores of the type variety are 4.8–8 x 2.7–4.8 μ, ellipsoid to cylindric or rarely reniform, thin-walled, or somewhat thick-walled, hyaline to slightly yellowish-hyaline; basidia 19–40 x 5–9.5 μ; cystidia none, or rare, but sometimes some aborted basidia present; the trama consists of a mediostratum (trama proper) with distinctly subparallel-interwoven thicker-walled hyphae which are more loosely arranged than in the hymenopodium; the latter strongly irregular, the hyphae running in all directions, many of them obliquely toward the subhymenium; the hyphae making up the hymenopodium are denser and slightly thinner and also have somewhat thinner walls than the hyphae of the mediostratum; the latter is distinctly continued above the dorsal end of the lamellae just below the context of the pileus as can be observed in most Boletineae. Paler to partially white carpophores are not infrequently observed in northern Europe, and have been described under various varietal names. For a complete description of this species, see Ann. Myc. **41:** 22. 1943, under *Clitocybe aurantiaca.* The type variety has not been observed as far south as Florida. We have observed only a single specimen of what we think is a dwarf form or a smaller race of this species since it is regularly stipitate and has the spores of the general measurements of this species. However, it was found on frondose trunk in low hammock, far from any conifers and this makes it more remarkable.

Var. **nana** Sing. var. nov.

Carpophoris minusculis, gracillimis et habitatione in truncis cavis arborum frondosarum in silva palustri subtropicali a typo differt.

Pileus brown, velutinous-tomentose, dry, convex, 6 mm. broad; margin smooth, initially involute. — *Lamellae* reddish orange, orange, narrow, forked, subobtuse at the edge, decidedly decurrent, descendant or arcuate, rather close; spore print not obtained. — *Stipe* dirty orange brownish, subvelutinous, solid, subequal, soft, 9 x 1 mm. — *Context* subconcolorous with the surfaces, soft, mild to the taste, inodorous.

Spores hyaline, 6–8 x 3.5–3.7μ, ellipsoid to subcylindric, smooth, non-amyloid; *basidia* 20–30 x 5–7.7 μ; *cystidia* none seen; *trama* as described in the type; *tomentum of the pileus* consisting of loosely interwoven hyphae, some of them slightly rough (from gelatinous matter), filamentous-cylindric, hyaline, 3–7 μ in diameter; all *hyphae* with clamp connections.

Chemical reactions: KOH, NH_4OH, and $FeSO_4$: little reaction.

Habitat: In the hollow trunk of living *Nyssa sylvatica*, in low hammock vegetation, far from conifers. Solitary in summer.

Distribution: Known only from the type locality.

Material studied: **Fla.:** Highlands Co., Highlands Hammock State Park, Sept. 1942. *R. Singer, F 640,* ***type*** (FH).

SPECIES INCERTAE SEDIS

Hygrophoropsis albida (Fr.) R. Maire, Publ. Inst. Botàn. **3**(4): 58. 1937.
Cantharellus albidus Fr., Syst. Mycol. **1:** 319. 1821.

This species has been described from Sweden. I have a few times collected specimens which I used to attribute to it, but since I have not recently restudied any of these, I hesitate to refer them here, for the available dried material is not well enough preserved to allow more detailed anatomical studies. *Cantharellus albidus* (*Hygrophoropsis albida*) does not occur in Florida. Maire thinks it belongs in this genus. He lists it in the family Leptotaceae, but the type genus of that family, *Leptotus*, belongs in the Cyphellineae, and has nothing in common with *Hygrophoropsis*, as a special study of the Leptotaceae showed (see R. Singer, The *Laschia*-complex. Lloydia **8:** 188. 1945.)

JUGASPORACEAE (Kühner *ut trib.*) Sing. (1936)

Characters of the family: pileus subglabrous to sericeous, smooth or more rarely venose, not viscid or scarcely viscid, small or rather large, the margin initially frequently involute, the color as in the whole carpophore usually pallid, white, more rarely light gray; hymenophore lamellose, lamellae decurrent if there is a stipe; spore print pink; context with more or less distinct farinaceous odor, more rarely subinodorous; stipe central eccentric, lateral or absent; veil none; spores hyaline to pale stramineous under the microscope, with 5–10 longitudinal ridges or veins or blunt angles formed by flattened stripes running from the hilar end to the apex, without germinative pore, thin-walled, the wall easily collapsing and the folds thus formed sometimes resembling additional ridges, young spores more smooth and rounded, ovoid, ellipsoid, fusoid, asymmetrical; cystidia none; hyphae of the cuticle and the surface of the stipe (if present) repent; trama consisting of a mediostratum of interwoven to subirregular hyphae with a generally axillar arrangement, and becoming more parallel-regular when seen at a point closer to the edge, conspicuously intermixed near the ground (dorsal part) of the lamellae, looser in the mediostratum, and the hyphae thicker than in the lateral stratum (hymenopodium) where some hyphae run obliquely toward the hymenium. The hyphae generally are irregularly interlaced, and in neither the mediostratum nor the lateral stratum are they as loosely arranged as in *Boletus*. The species are homothallic (*sec.* Kühner & Vandendries). All hyphae are without clamp connections.

Habitat: On the soil and on various organic material, wood, dung, dead Cormophyta, etc.

The Jugasporaceae form a very natural family. They have important characters in common with the Paxillaceae: the general appearance and biology, the shape and size of the spores, the structure of the trama (though the bilateral character of the latter is still less evident in the Jugasporaceae than it is in the Paxillaceae), the soft context, the occurrence of poroid hymenophores in aborted carpophores, the absence of cystidia (if *Paxillus involutus* is exempted), and the initially involute margin. On the other hand, it cannot be denied that there is a slight analogy with the Rhodogoniosporaceae, in the color of the spores in prints, the odor, and the frequent occurrence of pigmentless species. It is a fact that the sessile as well as the smaller stipitate forms of *Rhodophyllus* and *Clitopilus* are hard to distinguish if one has to rely on macroscopical characters only. It is just as true that some *Rhodophylli* with very rounded angles on the spores are equally hard to distinguish from the Tricholomataceae, such as *Rhodocybe* (cf. Lloydia **5**(2): 110. 1942). Lange relates *Clitopilus prunulus* to the Paxilli by putting it in a neighboring genus *Paxillopsis* Lange, but this latter genus is complex, containing all kinds of atypical Paxilli, including even *Rhodopaxillus*. Ricken, following Quélet, made *Clitopilus* a straight synonym of *Paxillus*, but his generic conception of *Paxillus* was still very broad, evidently under the influence of Quélet and Fries. Lundell, in *Fungi Exsiccati Suecici* #137 says: "Modern authors have placed it in the genus *Paxillus*. Lange justly eliminates *Clitopilus* altogether, and placed the smooth-spored species with *Paxillus*, and the angular-spored ones with *Eccilia*." Since Lundell understands *Paxillus* in a somewhat restricted sense, probably in approximately the same way as we do, his classification of *Clitopilus prunulus* within a restricted genus *Paxillus* goes much farther than I would go considering the differences between *Clitopilus* and *Paxillus*, especially in the spore color and clamp connections. Fayod (1889) comes closest to the point of view expressed in my papers since 1936. He has the following arrangement: Series D: Tribe 25 Goniosporés (the genera now considered as *Rhodophyllus*); Tribe 26 Paxillés (the genera here combined in the genus *Paxillus* and the genus *Gomphidius*); Tribe 27 Fusisporés (the genera here combined in *Clitopilus*). Fayod also admits the affinity of the Paxillés with certain boletes, but so did Opatowski in 1836.

The position of the Jugasporaceae in the classification of the Agaricales is one of the most difficult problems in spite of the large number of facts now available. If the similarity with the Rhodogoniosporaceae and *Rhodocybe* (in the first case the external similarity, in the latter case the similarity of the spores [4]) is considered to show affinity, we arrive at the

[4] The spores of *Rhodocybe alutacea* Sing. *ined.*, a species closely related to **R. truncata** (Fr.) Sing. comb. nov. ssp. *subvermicularis* (Maire) Sing. (*Rhodopaxillus truncatus* (Fr.) Maire var. *subvermicularis* Maire from North Africa, are at the same time warty because of thickenings of the wall, and when seen from above, obtusely applanate forming a hexagon. This latter character reminds one strongly of *Clitopilus*,

alternative solutions of this problem: either the Jugasporaceae are at the same time related with the Rhodogoniosporaceae (*Rhodophyllus*, *Rhodocybe*) on one hand, and the Paxillaceae on the other hand, or the Rhodogoniosporaceae and *Rhodocybe* would better be added to the Boletineae in the larger sense, or the Jugasporaceae could be combined with the family Rhodogoniosporaceae (*Rhodophyllus*, *Rhodocybe*). In view of the strong arguments in favor of an affinity with the Paxillaceae, and the plurality of possibilities suggested by the similarities with the Rhodogoniosporaceae and *Rhodocybe*, we think it best to leave the Jugasporaceae within the Boletineae at present, and wait for new facts to be found that might throw more light on the presumed affinity with other pink-spored agarics. It may well be that this affinity is not more than a certain coincidental similarity in spore shape.

Since the type concept, now obligatory in nomenclature, excludes the elimination of *Clitopilus*, and also its reestablishment in a modified sense as formerly advocated by R. Heim and myself, I cannot but follow the example of Konrad and Maublanc, R. Maire, Josserand, and others who use the genus *Clitopilus* in the way it is used in the present paper. The question of whether the smaller species should be kept in a separate genus (*Octojuga* Fay.), or combined with *Clitopilus*, is, as I have emphasized on several occasions, a question of the definition of the word genus. As it seemed before the entrance of certain intermediate species into the taxonomic picture of this family, the larger and the smaller species were well separated by several correlated characters, i.e. the striation and the size of the spores, the general appearance, and the habitat. Since then, however, it has turned out that minute species like *Omphalia Giovanellae* Bres. (see Mycologia **34:** 66. 1942) and *Omphalia scyphoides* Fr. belong here, species with central or eccentric stipe like *Clitopilus prunulus*, and also growing on the soil. The difference in the spores does not seem to be so important now since I have studied many species and specimens, and find that only the length of the spores is consistently though slightly different in the two groups. Two Indo-Chinese species, one of them (*C. crispus*) very similar to *C. prunulus*, have strongly 8–10–ribbed spores instead of 6–ribbed ones, and besides the spores are shorter than in *C. prunulus*. I therefore do not think that the differences as they appear now are sufficient for the establishment of two genera within the family Jugasporaceae, and, like Josserand (Bull. Soc. Myc. Fr. **53:** 209–213. 1937), I admit (*l.c.*) only one genus *Clitopilus*.

The longitudinal striation of the spores of the Jugasporaceae cannot be identified with the ridges of the spores in *Boletellus*. In the latter case, the optical section through the short axis of the spore shows terete spores with

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and as a matter of fact, Kühner has recently stated that in his opinion *Clitopilus prunulus* is related to certain species of *Rhodopaxillus* as he calls the clampless species which we refer to *Rhodocybe* in spite of the lack of pseudocystidia, *e.g. Rhodocybe fallax* (Quél.) Sing. Syn: *Rhodopaxillus fallax* (Quél.) R. Maire. See Bull. Soc. Linn. Lyon, Sept. et Oct. 1945, no. 7–8.

the veins or lamellose ridges projecting like thorns or wings, while in the Jugasporaceae we have a regular hexagon (with the angles slightly protracted or mucronate in *Clitopilus prunulus*) or heptagon, octagon, etc. In the latter case, the angles often are so obtuse that the striation of the spores is extremely difficult to observe, and only the outline of an optical section with the longer axis vertically directed towards the objective reveals the character of the spore. This character may also be obscured by the fact that young spores are more round in this position, and some do not seem ever to reach the striate stage. This is the case with *Clitopilus scyphoides*, and, to a lesser degree, *C. Passeckerianus*. But even then the color of the spore print should easily exclude the genus *Omphalia*, and the lack of clamp connections should exclude *Clitocybe*, *Dochmiopus*, etc.

Clitopilus (Fr.) Quél., Champ. Jura p. 120. 1872, *sensu* Patouillard, Hym. Eur., p. 113. 1887.
Agaricus trib. *Mouceron* Fr., Syst. Myc. **1:** 193. 1821.
Agaricus trib. *Clitopilus* Fr., Epicrisis, p. 148. 1836, *non* Syst. Mycol.
Hexajuga Fayod, Ann. Sci. Nat., sér. VII. **9:** 389. 1889.
Octojuga Fayod, Ann. Sci. Nat., sér. VII. **9:** 390. 1889.

Characters of the genus: they are the same as for the family. The type species is *Clitopilus prunulus* (Scop. *ex* Fr.) Quél. (*Agaricus prunulus* Fr.)

KEY TO THE SECTIONS AND SPECIES KNOWN TO THE AUTHOR

A. Carpophore medium to rather large, pileus 30–130 mm. broad, fleshy, with the external appearance of a larger *Clitocybe*, or *Paxillus involutus*; spores with 6 longitudinal furrows between 6 longitudinal folds or ridges, and therefore three-striate when seen in profile, (7)–10–14 μ long: growing on the soil.
Sect. *Prunuli*
6. *Clitopilus prunulus*

A. Carpophore smaller than indicated above, or spores smaller; spores either ridged as above, or seemingly smooth but appearing polygonal when seen from one end (with the longer diameter vertically directed toward the objective), 5.5–11.5 μ long, ridges or angles variable in number, usually more than 6, often up to 10; growing on the soil (mostly sand), or on various debris, rotting or rotten wood, manure, etc.
B. Stipe present, constantly persistent. Sect. *Scyphoides*
C. On horse manure in mushroom cellars; stipe very small, less than 3 mm. long. *Clitopilus Passeckerianus*
C. Not on manure, only in the open; stipe usually larger.
D. Pileus gray. 7. *Clitopilus Giovanellae*
D. Pileus white.
E. Spores with scarcely projecting ridges or folds, merely angular when seen from one end. 8. *Clitopilus scyphoides*
E. Spores with strongly (0.3–0.4 μ) projecting longitudinal ridges or folds.
F. Pileus fleshy with crenate margin. *Clitopilus crispus*
F. Pileus thin with smooth, entire margin.
Clitopilus orcelloides

B. Stipe absent, or spurious, or disappearing with age, or inconstant.
Sect. *Pleurotelloides*

G. On horse manure, in white-mushroom cellars. (Rare astipitate form of *Clitopilus Passeckerianus*)

G. On substrata other than manure.

H. Pileus rugose-venose; growing on the wood of evergreen trees in tropical hammock. 9. *Clitopilus venososulcatus*

H. Pileus smooth, or transparently striate. 10. *Clitopilus pleurotelloides*

Sect. **Prunuli** (Quél. ut sectio subgeneris *Orcellae* generis *Paxilli*, Ench., p. 92, 1886) *em.*

Carpophoris mediocribus vel majusculis, carnosis, distincte stipitatis; sporis 6 rugis longitudinalibus instructis, 10–14 μ longis. Ad terram.

Characters of the section: they are evident from the key and the Latin diagnosis above. Type species as in the genus *Clitopilus*.

6. **Clitopilus prunulus** (Scop. *ex* Fr.) Quél., Champ. Jura, p. 120. 1872.

Agaricus prunulus Scop. *ex* Fr., Syst. Mycol. **1:** 193. 1821.
Agaricus orcellus Bull. *ex* Fr., Syst. Mycol. **1:** 180. 1821.
Clitopilus orcellus Quél., Champ. Jura, p. 120. 1872.
Paxillus prunulus Quél., Enchir., p. 92. 1886.
Paxillus prunulus var. *orcella* Quél., Enchir., p. 92. 1886.
Hexajuga prunulus Fayod, Ann. Sci. Nat., sér. VII. **9:** 289. 1889.
Rhodosporus prunulus Schröter, *in* Cohn, Krypt.-Fl. Schles. **3**(1): 618. 1889.
Pleuropus prunulus Murr. N. Amer. Fl. **10**(2): 104. 1917.
Pleuropus obesus Murr., N. Amer. Fl. **10**(2): 105. 1917.
Paxillopsis prunulus Lange, Flora Agar. Dan. **4:** 48. 1939.

Pileus whitish, whitish-gray, whitish-cream, sometimes with spots, dots, or zones, sometimes scarcely subviscid during rains, but usually quite dry, mostly finely velutinous or innately mealy, convex but very soon flatter and depressed though usually very irregular, with involute, eventually irregularly-lobed margin, and obtuse, rarely indistinctly umbonate disc, smooth, 30–130 mm. broad. — *Hymenophore* white or whitish, then pale incarnate, easily separable from the context of the pileus, lamellae frequently not straight, moderately close to close, rather narrow or narrow (up to 4 mm. broad), deeply decurrent; spore print "fawn color." — *Stipe* white or concolorous with the pileus, slightly fibrillosely striate, glabrous or subglabrous, often with tomentose base, naked, versiform, solid, but softer inside, 26–50 x 6–21 mm. — *Context* white, soft, with the consistency of a bolete; taste mild, farinaceous; odor strong, farinaceous (of fresh flour, or flowers of *Berberis vulgaris*).

Spores elongate-ovoid to mostly subfusoid, with distinct suprahilar depression, with (5)–6–(7) longitudinal brims or edges which usually are more or less projecting, forming low ridges or folds with furrows running between them, the angular outline well-marked in an optical section with the long diameter of the spore vertically directed towards the objective (use chloral hydrate as medium), hyaline to hyaline-stramineous, asymi-

metric, (7)–10–14 x 5–6 μ, most frequently 10.5–12 x 5–5.8 μ; *basidia* 4–spored, 30–36 x 8.3–9.8 μ; *cystidia* and *cheilocystidia* none; *trama* of the lamellae intermixed-subbilateral, the mediostratum differing from the lateral stratum respectively the hymenopodium [5] in consisting of large, irregularly arranged elements in the basal (dorsal) portion of the lamellae, and generally in being less densely interlaced, and much thicker; toward the edge of the lamellae these differences become less distinct, the mediostratum becoming more regular and its elements more elongate and narrow, and even the hymenopodium becoming slightly less interlaced, its hyphae showing a slight but indistinct tendency to diverge toward the hymenium, 5.5–6μ in diameter; hyphae of the *cuticular* layer of the pileus repent, cylindric-filamentous; all *hyphae* consistently without clamp connections.

Chemical reactions: **NH_4OH,** yellowish-brown-vitreous. — **$FeSO_4$,** no reaction. — **Guaiacol** reacting only in the base of the stipe, and even there weakly and slowly. — **Methylparamidophenol,** negative to weak, or moderate reaction in stipe, no reaction or only a weak one on the pileus, the edges of the lamellae usually becoming distinctly deep umbrinous, in young specimens the surface of the pileus and the edges of the lamellae becoming distinctly deep violet but the rest of the carpophore remaining negative.

Habitat: In open woods and gardens, in meadows near isolated trees of all kinds, always on the soil, on sandy earth as well as on limestone; fruiting from May to November, usually in small groups.

Distribution: Europe, Caucasus, North Africa, North America south to Florida. In Florida known only from well-watered lawns in north Florida.

Material studied: **Fla.:** Alachua Co. Gainesville, some collections by *W. A. Murrill* (*Pleuropus obesus*) (FLAS); by *R. Singer F 1867, F 1867a* (FH). — **N. H.:** Chocorua, August 1904, *Farlow* (FH). — **Mass.:** Canton, August 1925, *D. H. Linder* (*C. orcellus*) (FH); Wakefield, August 1943, *R. Singer* (FH). — **N. Y.:** Newcomb Co., Mt. Goodenow, September 1941, *R. Singer* (FH). — **Ia.:** Iowa City, September 1936, *G. W. Martin* (FH). — **Tenn.:** Highlands, August 1936, *L. R. Hesler & A. J. Sharp* (FH). — **Canada: N. B.,** October 1903, *det.* Farlow (FH). — **U.S.S.R.:** Moscow region, Mikhailowskoe, June 1896, *Buchholz* (FH); Leningrad region, near Ryabovo, August 1938, *R. Singer* (*Hexajuga prunulus*) (LE). — **Spain:** Catalonia, Salardú, June to October 1934, *R. Singer* (BA). — Numerous collections of the fresh fungus in Czechoslovakia, Austria, Bavaria, and France, and abundant dried material from all European countries in the European herbaria. — Asiatic part of the **U.S.S.R.,** Caucasus, Abkhazia, Saken, August 1928, *R. Singer*; Caucasus, Guzeripl, August 1935, *L. N. Vassilieva* (KAZ).

This is an easily identified species, and one of the less-known but excellent edible mushrooms. *Clitopilus orcellus* is only an insignificant form of this species. Its occurrence in Gainesville, south of the 30th parallel, probably marks the southernmost limit of the species.

[5] What I call the hymenopodium, has been described by others as the subhymenium, *e.g.* by R. Maire for *Clitopilus cretaceus* Mre. (See also p. 538 and 547 of this paper.)

Sect. **Scyphoides** Sing. sect. nov.

Carpophoris vix mediocribus, aut sporis minoribus quam 10 μ et tunc carpophoris nonnunquam mediocribus vel submajusculis, constanter distincte stipitatis.

Characters of the section: compare the key p. 550, and the above Latin diagnosis. The type species is *Clitopilus scyphoides* (Fr.) Sing., more exactly var. *typicus* fa. *typicus*, as defined below, p. 554.

7. **Clitopilus Giovanellae** (Bres.) Sing., Mycologia **34:** 66. 1942.

Omphalia Giovanellae Bres., Fung. Trid. **1:** 9, *pl. 5, fig. 2.* 1881.

Pileus gray, sometimes somewhat shining, sericeous, smooth, but often subrugulose on the margin, and also slightly transparently striate at the extreme margin when wet and quite mature, not viscid, convex with a deep umbilicus in the center from the beginning, eventually becoming flatter to infundibuliform, 6–8 mm. broad (5–14 mm. according to Bresadola). — *Hymenophore* pale gray, easy to separate from the context of the pileus, lamellae very thin and slender, deep decurrent, arcuate, subclose to close, narrow; spore print pinkish. — *Stipe* grayish-white to gray, somewhat silky, central, or sometimes somewhat eccentric, subequal, very thinly and finely velutinous toward the base in many specimens, but in our Florida material never seen with white tomentum at the base, as described by Bresadola, solid or stuffed, 5–12 x 1–1.5 mm. — *Context* pallid, very brittle when dried, tender when fresh; *odor* very slightly farinaceous, almost inodorous in most cases; *taste* distinctly farinaceous but not bitter.

Spores 6–7 x 3.5–4 μ, smooth, with eight or less longitudinal flattenings bordered by obtuse or almost rounded edges, not or hardly visible even in chloral hydrate but the outline of an optical section clearly octagonal (or hepta- or hexagonal) when the longer diameter of the spore is pointing up toward the objective (like an egg seen "from above"), fusoid to ovoid, hyaline to stramineous-hyaline, at least the larger spores with a suprahilar depression, non-amyloid; *basidia* 16–25 x 6.8–8.3 μ; *cystidia* and *cheilocystidia* none; *gill trama* partly intermixed; all *hyphae* without clamp connections.

Habitat: Widely scattered on sandy places, in May and June (June and July in Italy).

Distribution: With certainty known only from Italy and north Florida, probably widely distributed but easily overlooked since it is rare and small, and often occurs in places where commonly no fungi are expected.

Material studied: **Fla.:** Alachua Co., Gainesville, June 1943, *R. Singer, F 2294* (FH); May 1943, *W. A. Murrill, det.* R. Singer, *F 2072* (FH). — **Italy: authentic,** from Gocciadoro, province of Trento, July 1899, *G. Bresadola* (NY).

Among the smaller species of *Clitopilus*, sect. *Scyphoides*, this species is well-determined by its color and the more or less central stipe, its occurrence on sunny, sandy places in spring. There is a minor difference between our Florida material and the Italian plant, i.e. the lack of the white tomen-

tum on the base of the stipe of the former. This is an interesting parallelism to what we have observed in the following species, *C. scyphoides*. In neither case should too much importance be attributed to this frequently variable character. Otherwise, our specimens agree perfectly with the authentic material cited above. *C. Giovanellae* is new for this continent.

8. **Clitopilus scyphoides** (Fr.) Sing. comb. nov. (*sensu lato*).

Agaricus scyphoides Fr., Syst. Mycol. **1:** 163. 1821 (equals var. *typicus* f. *typicus*).
Agaricus mutilus Fr., Syst. Mycol. **1:** 191. 1821 (equals var. *typicus* f. *mutilus*).
Omphalia scyphoides Quél., Champ. Jura, p. 99. 1872.
Pleurotus mutilus Gill., Champ. Fr. Hymen., p. 344. 1878.
Omphalina scyphoides Quél., Enchir., p. 42. 1886.
Clitopilus submicropus Rick, Broteria, **6:** 77. 1907 (equals var. *submicropus*).
Omphalina floridana Murr., Mycologia **33:** 440. 1941 (equals var. *floridanus*).
Pleuropus minimus Murr., Lloydia **5:** 144. 1942 (equals var. *floridanus*).
Clitopilus omphaliformis Joss., Bull. Mens. Soc. Linn. Lyon **10.** 1941 (*fide* Locquin, *ibid.* **13:** 107. 1944).

Var. **typicus** forma **typicus**

The European type of this species does not occur in Florida, but it is here redescribed for comparison with the American varieties. Pileus white, convex and umbilicate or infundibuliform from the beginning, not hygrophanous or subhygrophanous but with a dry, sericeous, very thin and sometimes indistinct sericeous covering, eventually undulate but with more or less regularly circular outline, 5–25 mm. broad. Hymenophore white to creamy white, eventually pallid to pinkish in fertile specimens, separable from the context of the pileus, lamellae narrow (up to 1.5 mm. broad), arcuate or horizontal-linear, or descendant, always decidedly and mostly deeply decurrent, subclose to crowded. Stipe white, slightly sericellous, typically short, 4–10 x 0.5–1.8 mm. (up to 2 mm. at the typically white tomentose, frequently thickened base), equal or subequal, flexuous or straight (typically more frequently flexuous), solid or stuffed, becoming hollow in age. Context white, thin; odor farinaceous or none; taste farinaceous and mild. Spores ellipsoid-oblong, or in smaller spores with a rhomboid outline, typically narrower than in var. *floridanus*, 7.5–11.5 x 4–5.5 μ, otherwise as in the variety; basidia mostly 4–spored, 17–28 x 6.5–8.5 μ; cystidia and cheilocystidia none; trama as in var. *floridanus*; cuticle of appressed, long, cylindric, smooth, clampless, 2.5–3.5 μ thick hyphae, making up the sericellous covering; neither the spores nor the hyphae are amyloid.

Habitat: Solitary or in small to large groups in moist or mossy meadows or fields, but also on the soil or on very decayed stumps in the woods, May to October, through most of Europe but I have never verified the indications from Siberia and South Africa. I have, however, made fresh collections in Bavaria, near Munich, where it is frequent in May and June on meadows, and I have examined the material in Lundell & Nannfeldt, Fungi Exsiccati Suecici (LE) as well as two specimens from the

Höhnel Herbarium (FH), one from Jenbach, *V. Höhnel B.2145*, one from near Trento, *F. v. Höhnel.*

Var. **typicus** f. **mutilus** (Fr. *l.c.*) Sing. comb. nov.

Clitopilus omphaliformis f. *calathinoides* Locquin, Bull. Mens. Soc. Linn. Lyon **13:** 107. 1944.

This form does not occur in Florida, but it is here redescribed for comparison with other forms and varieties, and because it has so often been misinterpreted. *Pileus* white, subhygrophanous, very slightly transparently striatulate when wet, not viscid, very minutely subfarinaceous-subsericellous, not circular but elongate in outline when old, often becoming lobate, tongue-shaped, or labiate-depressed, very eccentric to lateral, and in the latter case assuming the general appearance of *Arrhenia auriscalpium* (but larger), with initially incurved margin, 10–14 mm. broad. *Hymenophore* white, eventually somewhat pink, lamellae crisp, with rather obtuse edge when young, forked or simple, rather narrow, subrounded-attenuate or arcuate to the stipe, descendant-decurrent, close. *Stipe* white, solid, short white tomentose at the base, erect and straight, occasionally flexuous, very minutely mealy-sericellous, subequal, 5–17 x 1–1.5 mm. *Context* white, fragile, inodorous. *Spores* 6.8–8.5 x 3.5–5 μ as in the var. *floridanus*; *basidia* up to 26.5 x 5–8μ, 4–spored; *cystidia* and *cheilocystidia* none; *trama* intermixed, its bilaterality has not been checked by the author; hyphae without clamp-connections.

Habitat: On mossy north border of a mixed (*Pinus, Picea, Betula*) wood, growing among mosses (or actually on decayed needles scattered among these?).

Distribution: Certainly in Scandinavia, France, Finland, and also in the Leningrad region of the U.S.S.R., near Mga, August 21, 1938, *R. Singer & L. N. Vassilieva L37, 5–596* (LE). The above description was gathered from this latter collection. This form probably occurs in most of Europe.

Var. **floridanus** (Murr. *l.c.*) Sing.

PLATE I, FIG. 8–11.

Pileus white, pure white when dry, becoming sordid-pallid when old and wet, innately fibrillose-sericellous, smooth, or scarcely noticeably striatulate when wet, sometimes somewhat uneven, with the margin initially incurved, convex and umbilicate from the beginning, the umbilicus very deep, eventually the pileus deeply depressed, 8–20 mm. broad. — *Hymenophore* white or creamy white, eventually becoming pinkish in the fertile carpophores, easily separable from the context of the pileus, lamellae arcuate, decurrent to deeply decurrent, narrow (about 1 mm. broad), subclose to close, simple; spore print pale and dirty pink. — *Stipe* white, whitish, or sordid-pallid when old, glabrous or somewhat innately white-fibrillose, smooth, even, the base hardly noticeably mycelioid, versiform but usually as long as the pileus is broad, or longer, rarely shorter, and subequal, solid

or stuffed, sometimes becoming hollow, sometimes curved, 5–20 x 1–2.5 mm. — *Context* white, thin, very brittle when dried; odor farinaceous, or sometimes none; taste farinaceous, and slightly bitterish to mild.

Spores often agglutinate in fours, or in pairs, 6–10 x 3.7–5 μ, ellipsoid to ventricose-subfusoid, smooth, hexa- to octagonal because of (6)–8 flattened longitudinal ribs limited by obtuse or somewhat rounded edges which are not or hardly visible even in chloral hydrate, but become evident in an optical section with the long diameter of the spore pointing upward to the objective (like an egg seen "from above"), the wall thin and very easily collapsing, especially along the longitudinal edges, and then often appearing longitudinally ridged, some with a slight suprahilar depression, some only with an applanation, non-amyloid, hyaline to stramineous-hyaline; *basidia* 17–26.5 x (5)–6.7–9.5 μ, 4–spored, sometimes some 2– to 3–spored; *cystidia* and *cheilocystidia* none, but in some specimens many basidia abortive; *gill-trama* intermixed- subbilateral, non-amyloid, the hyphae without clamp connections; *cuticle* of the pileus (the thin silky covering) consisting of long, cylindric, appressed, smooth, more or less interwoven, clampless hyphae of 2–5.3 μ diameter, forming a loose to subdense tissue.

Chemical reactions: **$FeSO_4$,** somewhat grayish, almost negative. — **Methylparamidophenol,** negative.

Habitat: On open lawns, on bare ground and among grasses, also on roadsides and near the hammocks, never in the hammocks, fruiting from May to October. Gregarious.

Distribution: Common all over Florida.

Material studied: **Fla.:** Dade Co., Miami SW, 15th Road, October 1942, *R. Singer F 1216/II* (FH); Highlands Co., Highlands Hammock State Park, August 1942, *R. Singer F 465* (FH); Alachua Co., Gainesville, several collections, among them **type** of *Omphalina floridana, W. A. Murrill F 16223* (FLAS); and **type** of *Pleuropus minimus* Murr., *W. A. Murrill, F 19980* (FLAS, FH).

Var. **submicropus** (Rick *l.c.*) Sing. comb. nov.

Pileus as in var. *floridanus*, but more distinctly sericeous or sericeous-fibrillose, smooth, convex with depressed center, larger, 20–30 mm. in diameter. — *Hymenophore* as in var. *floridanus*, close to crowded, sometimes somewhat forked; spore print pale and dirty pink. — *Stipe* white or pallid, innately fibrillose to somewhat mealy, especially on the apex, smooth, the bases connected by a very thin mycelioid membrane, solid, equal, but frequently with slightly thickened base and apex, sometimes flexuous, 10–25 x 2–4 mm. — *Context* white, very brittle when dried and also more or less fragile when fresh, rather thin; odor farinaceous; taste slightly bitter to mild.

Spores often agglutinate in pairs or in four, 5.5–6.8 x 3.5–4 μ, shaped as in var. *floridanus*; *basidia* 17 x 6.8 μ; *cystidia* and *cheilocystidia* none seen; *hyphae* without clamp connections.

Habitat: In the hammocks (tropical hammock formations in Florida), on small debris and sticks, gregarious to cespitose, fruiting in Florida in October.

Distribution: Tropical Florida and Brazil, possibly all over tropical America.

Material studied: **Fla.:** Dade Co., Matheson Hammock, October 1942, *R. Singer F 1252* (FH). — **Brazil: type,** Rio Grande do Sul, 1906, *J. Rick* (FH).

Rick indicates the spores as being 6 x 2.5 μ, but in the type specimens I have found many foreign spores as well as many collapsed spores of the *Clitopilus*, and some of these fit in Rick's measurements. However, the non-collapsed spores of Rick's specimen perfectly agree with the above measurements taken from my Florida collection.

Var. aff. **floridanus,** ined.

Pileus as in the type variety but less distinctly sericellous. *Hymenophore* as in the type variety but often sterile. *Stipe* as in the type variety but less silky, more elongate in general and more frequently straight, sooner becoming hollow in large specimens, 3–17–(24) x 0.7–2 mm., the base glabrous in some specimens, white tomentose in others (inconstant). *Context* white, not very fragile, but very brittle when dried; odor farinaceous only when the carpophores are squeezed. *Spores* 7.7–9 x 4.5–5.2 μ (specimen from North Dakota); *basidia* 17.5–27.5 x 6.5–8.5 μ, 2–, 3–, or 4–spored (very variable); *cystidia* and *cheilocystidia* none; *trama* and *cuticle* as in var. *floridanus*.

Habitat: On well-watered lawns on the soil, also in swamps on decayed leaves and wood, and on burned-over prairie sod, fruiting from June to August, gregarious.

This is another form, close to var. *floridanus* (Murr.) Sing., but obviously not entirely identical with it, found in the northern and western states.

Material studied: **Vt.:** Middlebury, July 1897, *E. A. Burt* (FH). — **Mass.:** Woburn, August 1943, *W. L. White, det.* Singer (*sterile form*) (FH). — **N.D.:** Kulm, June 1923, *J. F. Brenkle* (under a new unpublished name), N. Dakota Fungi *1613*.

Sect. **Pleurotelloides** Sing. sect. nov.

A sectione praecedente stipite inconstanter formato vel haud persistente aut rudimentario vel complete absente differt.

Characters of the section: these are evident from the key p. 551, and the above Latin diagnosis. Type species: *Clitopilus pleurotelloides* (Kühn.) Sing.

9. **Clitopilus venososulcatus** Sing. spec. nov.

Pileo pallide albo, radiato-sulcato et venoso, farinaceo, sessili vel subsessili, 12–23 mm. lato; lamellis concoloribus, satis angustis, postice attenuatis, confertis; sporis in cumulo roseolis, 8–8.5 x 4.5–5 μ, substramineis, striatulis; stipite nullo vel minutissimo, usque ad 1.3 x 0.6 mm.; carne inodora. Habitatio: Ad lignum emortuum prope Miami Floridae, U. S. A.

Pileus pallid white, radially venose and sulcate, mealy, not viscid, sessile or subsessile, 12–23 mm. broad. — *Hymenophore* white or pallid, becoming

dotted with pink from the spores, lamellae rather narrow (1.5–2 mm. broad), close, attenuate behind; spore print pinkish on white paper. — *Stipe* absent or rudimentary, and then concolorous and minutely mealy, not larger than 1.3 x 0.6 mm. — *Context* white, inodorous, very thin, very fragile.

Spores hyaline to pallid-stramineous, ellipsoid or short ventricose-subfusoid, or somewhat ovoid, longitudinally substriate because of flattened ribs limited by obtuse edges, in optical cross section obscurely angular, hexagonal or octagonal, 8–8.5 x 4.5–5 μ; *basidia* 20–21 x 7–7.5 μ; *cystidia* and *cheilocystidia* none seen; all *hyphae* without clamp connections.

Habitat: On dead portions of standing trunks of living *Ficus aurea*, and also on logs from the same host. October.

Distribution: Coastal Hammock in south Florida.

Material studied: **Fla.:** Dade Co., Matheson Hammock, October 29, 1942, *R. Singer F 1344*, **type** (FH).

This species is close to *C. pinsitus* (Fr.) Josserand and *C. pleurotelloides* (Kühn.) Sing. It differs from both in the venose surface, and from the latter species also in being larger.

10. **Clitopilus pleurotelloides** (Kühn.) Sing. comb. nov.

Octojuga pleurotelloides Kühner, Le Botaniste **17:** 158. 1926.
Octojuga variabilis (Fr. *sensu* Karst. p. p., *non al.*) Fayod, Ann. Sci. Nat., sér. VII. **9:** 390. 1889.
Clitopilus variabilis Josserand, Bull. Soc. Myc. Fr. **53:** 212. 1937.
Octojuga Fayodi Konr. & Maubl., Icon. Sel. Fung. **6:** 234. 1924–36.
Geopetalum viticola Murr., Bull. Torr. Bot. Club **67:** 2. 1940.
Pleurotus viticolus Coker, Journ. E. Mitch. Sci. Soc. **60:** 92. 1944.

Pileus pallid white, frequently becoming somewhat dirty grayish cream in age, opaque, white tomentose in the zone nearest to the substratum, smooth or transparently striatulate when moist, at least in the marginal zone when quite mature, glabrous but sericeous or finely villous when seen under a lens, circular, semicircular, or reniform, convex, sometimes attached by a resupinate portion and the free margin horizontally deflexed, the margin initially incurved, then repand and straight and occasionally radiately splitting, largest diameter of the non-resupinate portion of the pileus 1.5–10 mm. — *Hymenophore* pallid, lamellae moderately broad to very broad, subclose to rather distant, inserted, with entire or slightly uneven edges; spore print pale cinnamon pink. — *Stipe* absent, or present in very young specimens and then up to 1 mm. long, but soon becoming rudimentary and button-like, or entirely disappearing, concolorous, subpruinose to sericeous. — *Context* concolorous, very fragile, brittle when dried; odor none or very slight, farinaceous; taste mild.

Spores 5.5–9 x 3.5–5.8 μ (according to Kühner up to 12 x 6.2μ), stramineous-hyaline, non-amyloid, ellipsoid to ovoid in outline but slightly hexagonal, octagonal, or decagonal with flattened to very slightly concave sides when seen in optical cross section, from one end; *basidia* 25–29 x

7.5–8.5 μ, 4–spored or a few 2–spored; *cystidia* and *cheilocystidia* none; *trama* non-amyloid; *hyphae* of the sericeous covering of the pileus cylindric, subinterwoven with some semi-erect ends, 2–4 μ thick, all hyphae without clamp connections.

Habitat: On dead cortex of tree trunks, on logs and dead branches, vines, (*Quercus*, *Eucalyptus*, *Salix*, according to R. Maire, *Cornus florida* and *Vitis* spec. according to Coker), and also on fallen needles of conifers, dead thallus of mosses (*Hypnum* according to Kühner), on bark of *Zizyphus jujuba*, also on herbaceous stems; June to December.

Distribution: Europe, Asia, and America, possibly cosmopolitan but often overlooked or misdetermined.

Material studied: **Fla.: type** of *Geopetalum viticola*, Alachua Co., Arredonda, 1938, *Erdman West & W. A. Murrill* (FLAS).—**USSR:** (formerly Finland), Kellomäki, Sept. 1940, *R. Singer 5–836* (LE).—**India:** Ladhar, Sheikhupura, *Sultan Ahmed*, August 1944 (*det.* Singer), *1097* (FH).

Fayod based his name on an observation by Karsten, Mycol. Fenn. **3:** 112. 1876: "Occurrit forma sporis minoribus (longit. 6 mm., crassit. 3–4 mm.), subhyalinis, qvalem in ramulis *Salicis Capraeae* prope Åbo mense Aug. legimus." Åbo is now Turku, Finland, and it may be of interest that I collected this species in Finland (or what formerly was Finland) on debris of rotten moss among sand near the railway station of Kellomäki, September 1940. There is, therefore, little doubt that Fayod was right in attributing this variety to what we now call *Clitopilus pleurotelloides*. But the type variety of *Agaricus variabilis sensu* Karsten is, as I have been able to confirm on the basis of Karsten's exsiccatum of this species distributed by him under #511 of the Fungi Fennici, determined correctly in the sense of the majority of the authors, *i.e.* it is a typical *Dochmiopus* (Agaricineae) with rough spores. Kühner was, therefore, justified in erecting a new name for the *Clitopilus* reserving the epithet "*variabilis*" for the *Dochmiopus*. The American collections do not differ sufficiently to separate them from *C. pleurotelloides*. They are, perhaps, slightly thinner with the lamellae accordingly broader and the surface of the pileus accordingly more striatulate, but striations are frequent in European specimens also, and the size of the lamellae and the diameter of the flesh vary considerably. The spores are slightly smaller in the types than they are in the European specimens I have studied, but Coker, who has re-collected Murrill's form in North Carolina, gives spore measurements which are exactly intermediate to almost identical with my European measurements (6.7–9 x 4.8–5.8 for the Kellomäki collection, 5.5–8 x 3.5–4.8 μ for Murrill's type). This again shows that the size of the spores is variable in this country as well as in Europe, though not more so than in some other species of this same genus. Murrill observes that "not one individual was found entirely resupinate, nor was there a stipe in the entire lot." If this latter observation should hold true for all American collections, including the youngest stages, it would be possible to distin-

guish Murrill's species as a form or variety of *C. pleurotelloides*. I doubt very much that the astipitate character of the American form is constant since it is not constant in the European plant.

EXTRALIMITAL SPECIES

Clitopilus crispus Pat., Bull. Soc. Myc. Fr. **29:** 214. 1913.

The type has been described from Indo-China. These specimens and an excellent colored picture are preserved at the Farlow Herbarium. There is also a spore print on blue paper which when transferred on white paper now is between "fawn color" and "wood brown." The mature spores are stramineous under the microscope, or, in dense piles, succineous, ellipsoid with some tendency to become hexagonal, with seven to ten (mostly eight) angles reinforced by longitudinal ribs and with furrows between them when seen in an optical cross section from one end, the ribs projecting about 0.4 μ, 6.8–8.8 x 4.3–5.2 μ. This species is by far the stoutest of the small-spored *Clitopili*, but, nevertheless, belongs in the section *Scyphoides*.

Clitopilus orcelloides Pat. & Demange, Bull. Soc. Myc. Fr. **26:** 40. 1910.

The type, preserved in the Patouillard Herbarium (FH), comes from Indo-China. It has spores exactly as described by Patouillard, *i.e.* ellipsoid-subhexagonal or subrhomboid, or equally ovoid-ellipsoid, octagonal when seen from above, and then the angles reinforced by longitudinal veins which in the optical cross section look like knots, 5.5–7.5 x 3.7–5.3 μ, sometimes as short as 6 x 5.2 μ, the ribs projecting up to 0.3 μ; hymenium and trama not very distinct in these specimens. There is an excellent colored picture in the unpublished "album" of V. Demange, executed by a native artist, and representing the type specimens in fresh condition. These vividly recall *Clitopilus scyphoides* var. *floridanus* from which the dried specimens are difficult to distinguish. However, the more angular spores, many of which are ornamented with ribs, cause me to consider *C. orcelloides* a different though related species of the section *Scyphoides*.

Clitopilus Passeckerianus (Pilát) Sing., Mycologia **34:** 66. 1942.

Pleurotus Passeckerianus Pilát, Atl. Champ. Eur., *Pleurotus* Fr., Ser. A, **9–10:** 49. 1935.

Pleurotellus Passeckerianus Konr. & Maubl., Icon. Sel. Fung. **6:** 361. 1938.

Octojuga Passeckeriana Sing., Ann. Mycol. **40:** 61. 1942.

This is a frequent weed-fungus in white-mushroom beds, and in my opinion is slightly different from *C. pinsitus* as well as from *C. scyphoides* var. *typicus* f. *mutilus* and *C. pleurotelloides*. For more descriptive data see the original account of Pilát, (1935) with photographs, and also Singer, (1942).

SPECIES IMPERFECTLY KNOWN

Clitopilus pinsitus (Fr.) Josserand, Bull. Soc. Myc. Fr. **53:** 210. 1937.

Agaricus pinsitus Fr., Syst. Mycol. **1:** 184. 1821.

This species, originally described from Sweden, has been redescribed by Josserand from France. Though it is impossible to prove that Josserand's interpretation is the only correct one, it seems to me that it is the best emendation of an otherwise superfluous Friesian species. I have not collected it myself, nor has it been found in America. It differs from *C. pleurotelloides* in being much larger and in having close, narrow lamellae.

SPECIES DUBIAE

Clitopilus cretatus (Berk. & Br.) Sacc., Syll. **5:** 702. 1887.

Described from England, this species is thought by Lange to be the same as *Pleurotus mutilus, i.e. Clitopilus scyphoides* var. *typicus* fa. *mutilus*. However, R. Maire (Publ. Inst. Botàn. **3**(4): 83. 1937) refers it to his genus *Clitopilopsis* because of Massee's indication on the spores of the type specimen of *Agaricus cretatus* Berk. & Br., Ann. Mag. Nat. Hist. ser. III. **7:** 373. 1861. In Massee's paper (Grevillea **21:** 81. 1893) are some not quite trustworthy measurements, and it may be unwise to take his word for it that these spores are not of the *Clitopilus*-type. A re-examination of the types at Kew will decide whether *C. cretatus* is another synonym of *C. scyphoides*, or a good species in some other genus.

SPECIES EXCLUDENDAE

Clitopilus abortivus (Berk. & Curt.) Sacc., Syll. **5:** 701. 1887.

This species, common in north Florida in winter, does not belong in this genus, but must be called *Rhodophyllus abortivus* (B. & C.) Sing., Rev. d. Mycologie **5:** 9. 1940. Other species formerly called *Clitopilus*, but having angular spores of the *Rhodophyllus*-type, must also be placed in the genus *Rhodophyllus* rather than *Clitopilus*. These are *C. undatus* Fr. (*ut Agaricus*), *C. cancrinus* Fr. (*item*), *C. albogriseus* Peck (*item*) (*Rhodophyllus albogriseus* (Peck) Sing., *recte*), and many others.

Clitopilus pallidus Heim, Treb. Mus. Ciènc. Nat, Barcelona **15**(3): 109. 1934.

Since *Clitopilus* is now used in the sense of Patouillard and Maire, the species of *Clitopilus em.* Heim, *l.c.* must go into *Clitopilopsis* Maire (Agaricineae). The type species of *Clitopilopsis* is *C. pallida* (Heim) Maire from Spain. Another species to be excluded is *Clitopilus togoensis* Henn., also considered to belong in *Clitopilus em.* Heim by Heim (1934) and Singer (1936), and certainly belonging in the Agaricineae rather than in the Jugasporaceae.

GENERA EXCLUDENDA

The following genera formerly considered to be allied to the boletes or other groups of the Boletineae, are now excluded from this suborder.

Filoboletus Henn. (belongs to the Tricholomataceae, Agaricineae).
Polyporoletus Snell (belongs to the Scutigeraceae, Clavariineae).
Fistulina Bull. *ex.* Fr. (belongs to the Fistulinaceae, Cyphellineae).
Volvoboletus Henn. (is a parasitized or abnormal *Amanita*).

GENERA DUBIA

Fistulinella Henn.
Melanomphalia Lange.
Gymnogomphus Fayod.

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THE MOST IMPORTANT LITERATURE ON THE BOLETINEAE, ESPECIALLY THOSE OF FLORIDA

Atkinson, G. F. Studies on American Fungi, Mushrooms. p. I–VI, 1–275. Ithaca. 1900.

Barbier, M. Les Bolets. p. 1–30. Besançon. 1908.

Beardslee, H. C. New and interesting fungi. Mycologia **26:** 253–260. 1934.

Beck, G. v. Mannagetta, Versuch einer systematischen Gliederung der Gattung *Boletus* L. em. Zeitschr. Pilzk. **2:** 141–149. 1923.

Beeli, M. Contribution nouvelle à l'étude de la flore mycologique du Congo. Bull. Soc. R. Bot. Belg. **58:** 203–216, *pl. 15–16.* 1926.

Bresadola, G. Iconographia Mycologica. **19:** *pl. 901–944.* Mediolani. 1931.

Coker, W. C. & A. H. Beers. The Boletaceae of North Carolina. p. I–VIII, 1–96, *pl. 1–65*, and *front.* Chapel Hill. 1943.

Elrod, R. P. & D. L. Blanchard. Histological studies of the Boletaceae and related genera. Mycologia **31:** 693–708. 1939.

Farlow, W. G. (edited by E. A. Burt) Icones Farlowianae. p. I–X, 1–120, *pl. 1–103.* Cambridge, Mass. 1929.

Fayod, V. Prodrome d'une histoire naturelle des Agaricinées. Ann. Sci. Nat. Bot. VII. **9:** 181–411. 1889.

Fries, E. M. Systema Mycologicum. **1:** 385–395. 1821.

Fries, E. M. & C. T. Hök, Boleti Fungorum Generis Illustratio. 14 pp. 1835.

Frost, C. C. Catalogue of Boleti of New England, with description of new species. Bull. Buff. Soc. Nat. Sci. **2:** 100–105. 1874.

Gilbert, E. Les Bolets, p. 1–255. Paris. 1931.

Gray, S. F. A Natural Arrangement of British Plants, **1:** 1–824. 1821.

Heim, R. Notes sur la flore mycologique Malgache III. Rev. d. Mycol. **1:** 3–18. 1936; VII. Rev. d. Mycol. **4:** 5–20. 1939.

Josserand, M. Sur la nature de la trame dans les genres Paxillus et Phylloporus. Bull. Soc. Myc. Fr. **48:** 112–117, *pl. 13.* 1932.

———. Notes critiques sur quelques champignons de la region Lyonnaise. Bull. Soc. Myc. Fr. **53:** 175–230, *pl. 6.* 1937.

Kallenbach, F. Die Röhrlinge *in* Pilze Mitteleuropas **1** (1–19): 1–138, *pl. 1–52.* 1926–38.

Kauffman, C. H. The genus Gomphidius in the United States. Mycologia **17:** 114–126, *pl. 12–14.* 1925.

Kavina, K. Česke Slizaky. Trav. Mycol. Tchécoslov. **2:** 1–8, *1 pl.* 1924.

Karsten, P. A. Enumeratio Boletinearum et Polyporearum Fennicarum systemate novo dispositarum. Rev. Mycol. **3:** 16. 1881.

Killermann, S. Pilze aus Bayern. Denkschr. Bayer. Bot. Ges. Reg. **16:** 1–23. 1925.

Konrad, P. Un dernier mot sur la classification des Bolets. Bull. Mens. Soc. Linn. Lyon **3:** 1–4. 1934.

Konrad, P. & A. Maublanc. Icones Selectae Fungorum. **4–6.** 1924–1937.

Lohwag, H. & M. Peringer. Zur Anatomie der Boletaceae. Ann. Mycol. **35:** 295–331. 1937.

Murrill, W. A. The Boleti of the Frost Herbarium. Bull. Torrey Bot. Cl. **35:** 517–526. 1908.

———. The Boletaceae of North America. Mycologia **1:** 4–18; 140–160. 1909.

———. Agaricales. (Boletaceae) N. Amer. Fl. **9**(3): 133–161. 1910.

———. New Boletes. Mycologia **30:** 520–525. 1938.

———. Three new Boletes. Mycologia **31:** 110–112. 1939.

———. Addition to Florida fungi. Bull. Torrey Bot. Cl. **67:** 57–66. 1940.

———. New fungi from Florida. Lloydia **5:** 136–157. 1942.

———. Florida Boletes (Boletaceae). Mim. Contrib. Herb. Univ. Fla. Agric. Expt. Sta. p. 1–6. 1942.

———. More new fungi from Florida. Lloydia **6:** 207–228. 1943.

———. More fungi from Florida. Lloydia **7:** 303–327. 1944.

Opatowski, G. Commentatio Historico-naturalis de Familia Fungorum Boletoideorum. Diss. inaug. Berlin 1836 (also *in* Wiegmann's Archiv. **2:** 1–34. 1836).

Patouillard, N. & C. F. Baker. Some Singapore Boletinae. Jour. Straits Branch R. A. Soc. **78:** 67–72. 1918.

Peck, C. H. Genus Boletus. Rep. N. Y. State Cab. **23:** 127–133. 1872.

———. The Boleti of the United States. Bull. N. Y. State Mus. **2**(8): 73–166. 1889.

Persoon, C. H. Mycologia Europaea **2:** 123–148. 1825.

Pilát, A. *in* Kavina, K. & A. Pilát. Atlas des Champignons de l'Europe: *Pleurotus.* Praha. 1935.

Quélet, L. Enchiridion Fungorum in Europa et praesertim in Gallia vigentium, p. I–VI, 1–352. 1886.

———. Flore Mycologique de France. p. I–XVII, 1–492. Paris. 1888.

Rostkovius, F. W. T. *in* Sturm, J. Deutschlands Flora III **5:** 1–132, *pl. 1–48.* 1844.

Saccardo, P. A. Sylloge Fungorum. **5, 6, 9, 11, 14, 16, 17, 19, 20, 21, 23.** Patavii. 1887–1925.

Secretan, L. Mycologie Suisse. **3:** I–VIII, 1–760. Genève. 1833.

Singer, R. Sur les genres Ixocomus, Boletinus, Phylloporus, Gyrodon et Gomphidius. Rev. de Mycol. **3:** 35–53, 157–177. 1938.

———. Notes sur quelques Basidiomycètes. VI. Rev. de Mycol. **5:** 3–13. 1940.

———. Das System der Agaricales I. Ann. Mycol. **34:** 286–378. 1936; II. **40:** 1–132. 1942.

———. New genera of fungi. Mycologia **36:** 358–368. 1944.

———. The Boletineae of Florida. I. Farlowia **2:** 97–141. 1945. II. Farlowia **2:** 223–303. 1945. III. Amer. Midl. Nat. (in press).

Slipp, A. W. & W. H. Snell. Taxonomic-ecologic studies of the Boletaceae in northern Idaho and adjacent Washington. Lloydia **7:** 1–66, *pl. 1–8.* 1944.

Smotlacha, F. Monografie ceských hub hribovitych (Boletinei). Vestn. česk. spol. nauk **2**(8): 1–73. 1911.

Snell, W. H. Notes on Boletes I. Mycologia **24:** 334–341. 1932; II. Mycologia **25:**

221–232. 1933; III. Mycologia **26:** 348–359, *pl. 41.* 1934; IV. Mycologia **28:** 13–23. 1936. V. Mycologia **28:** 463–475. 1936.

————. Tentative keys to the Boletaceae of the United States and Canada. Publ. No. I. Rhode Island Bot. Cl. 1–25. 1936.

————. The genera of Boletaceae. Mycologia **33:** 415–423. 1941.

————. New proposals relating to the genera of the Boletaceae. Mycologia **34:** 403–411. 1942.

———— & E. A. Dick, Notes on boletes VI. Mycologia **33:** 23–37. 1941.

Yates, H. S. A comparative histology of certain Californian Boletaceae. Univ. Calif. Publ. Bot. **6**(10): 221–247, *pl. 21–25.* 1916.

EXPLANATION OF PLATE I

All figures are drawn at a magnification of × 2000.

Fig. 1–3. *Gomphidius rutilus* (Fr.) Lund. & Nannf. ssp. *alabamensis* (Earle) Sing.

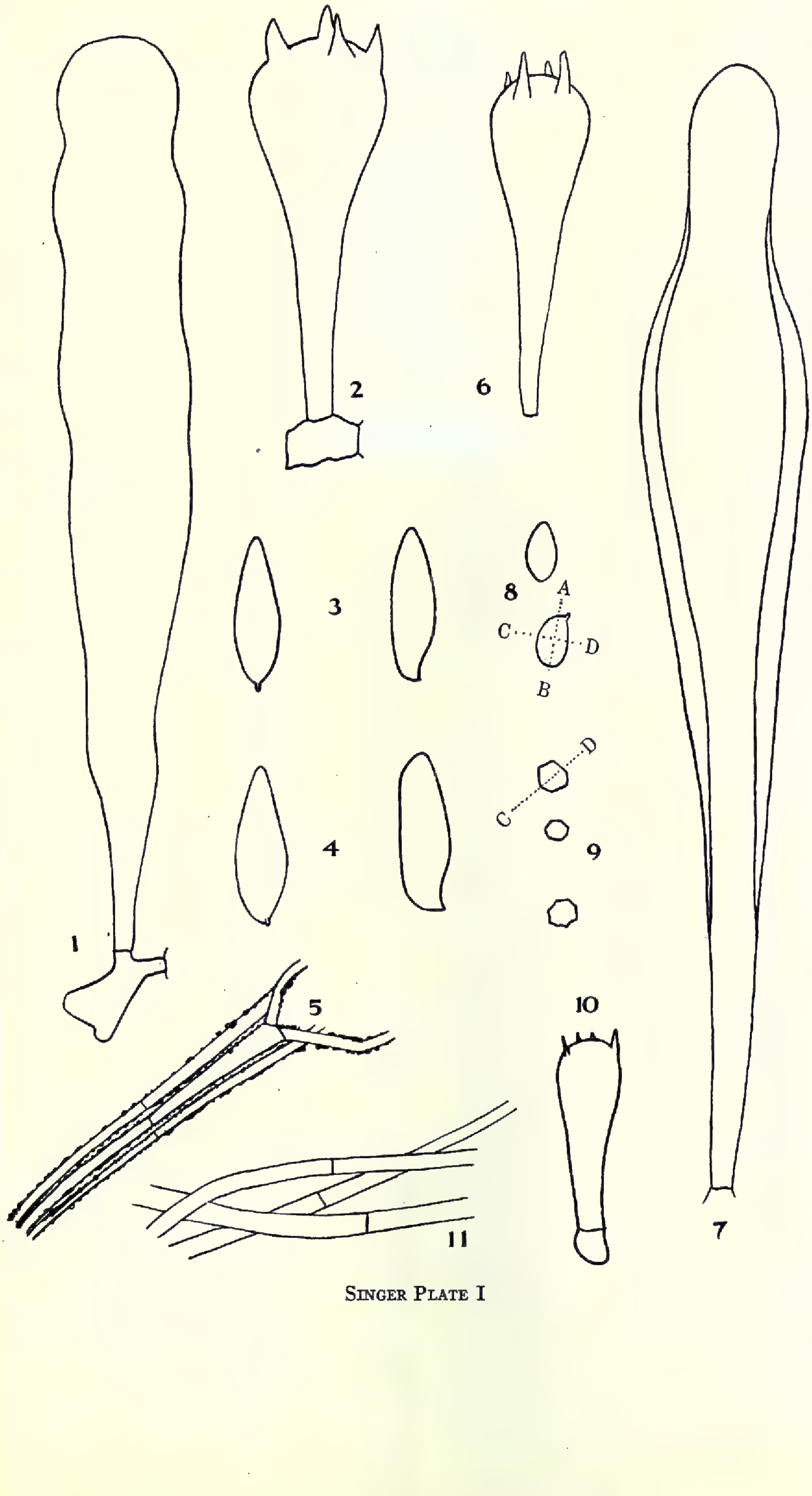
1. Cystidium.
2. Basidium.
3. Two spores, (left) frontal view; (right) in profile.

Fig. 4–7. *Gomphidius vinicolor* Peck ssp. *jamaicensis* (Murr.) Sing.

4. Two spores, (left) nearly-frontal view; (right) in profile.
5. Hyphae of the remainders of the veil on the apex of the stipe, running in parallel strands, with strong pigment-incrustation.
6. Basidium.
7. Cystidium with the partially thickened wall.

Fig. 8–11. *Clitopilus scyphoides* (Fr.) Sing. var. *floridanus* (Murr.) Sing.

8. Two spores, (above) in frontal view; (below) in profile with the hilar end above; the line A . . . B indicates the longitudinal axis, C . . . D the short axis.
9. Three spores, seen from above (the longitudinal axis A . . . B vertically directed toward the lens), the short axis indicated corresponding to fig. 8, lower spore, as C . . . D. The upper spore shows 6 flattened sides and 6 angles, central one 7, the lowest 8 (which is the normal number in this form).
10. Basidium.
11. Hyphae of the sericeous covering of the pileus.



SINGER PLATE I

2(4): 569–580 FARLOWIA July, 1946

INDEX TO VOLUME 2

Index to Authors and Titles

Abbott, Isabella A. The genus Griffithsia (Rhodophyceae) in Hawaii, **439–453.**

Bartram, Edwin B. New mosses from Tierra del Fuego, **309–319.**

Chardon, Carlos E. Fungi Domingenses novi vel minus cogniti. I, **455–473.**

Cutter, Victor M., Jr. The genus Cunninghamella (Mucorales), **321–343.**

Harris, Hilda F. The correspondence of William G. Farlow during his student days at Strasbourg, **9–37.**

Linder, David H. In honor of William Gilson Farlow, **1–7.**

Patrick, Ruth. A taxonomic and ecological study of some diatoms from the Pocono plateau and adjacent regions, **143–221.**

Prince, Alton E. The biology of Gymnosporangium nidus-avis Thaxter, **475–525.**

Roberts, Catherine. A comparative study of Torulopsis pulcherrima and Taphrina deformans in culture, **345–383.**

Singer, Rolf. The Boletineae of Florida with notes on extralimital species. I. The Strobilomycetaceae, **97–141;** The Boletineae of Florida with notes on extralimital species. II. The Boletaceae (Gyroporoideae), **223–303;** The Boletineae of Florida with notes on extralimital species. IV. The lamellate families (Gomphidiaceae, Paxillaceae, and Jugasporaceae, **527–567;** Notes on Farlow's Agaricales from Chocorua, **39–51.**

Taylor, Wm. Randolph. William Gilson Farlow, promoter of phycological research in America 1844–1919, **53–70.**

Verdoorn, Frans. Farlow's interest in an international abstracting journal, **71–82.**

Weston, William H., Jr. Dr. Farlow's influence on mycology, **84–95.**

Whelden, Roy M. Note on Argentine Charas, **305–308.**

Whetzel, H. H. The cypericolous and juncicolous species of Sclerotinia, **385–437.**

INDEX TO GENERA AND SPECIES

New names and the final members of new combinations, and the pages on which they occur, are in **bold-faced type;** in taxonomic papers, where the main treatment of a genus or species is given, the page number only is in **boldface.** Synonyms and the pages on which they occur are printed in *italics.*

Achnanthes 166–170, *213*; subgen. Achnanthes 166, 169; subgen. Achnanthidium 166; subgen. Microneis 166; coarctata 166; exigua 167; hungarica 167; lanceolata 166, 167, 169, *211*, *212*; lanceolata var. **apiculata 167;** lanceolata var. Oestrupii 169; lanceolata var. robusta 168; lanceolata var. rostrata 168; **Lewisiana** 166, **168;** linearis 167, 168, *207*; microcephala 167, 169; minutissima 167, 169; minutissima var. cryptocephala 169; Oestrupii 166; Oestrupii var. **parvula 169;** Peragallii 166, 169; **Stewartii 169–170;** Suchlandtii 168

Achnanthidium subgen. 166; *coarctatum 166; hungaricum 167; lanceolatum 167; lineare 168; microcephalum 169*

Actinocephalum 323, *325;* japonicum 323, **334**

Aecidium *nidus-avis 481*

Agaricineae 527, 562

Agaricus trib. *Clitopilus 550*; trib. *Mouceron 550*; *cretatus 561; croceolamellatus 541*; involutus 540; *lamellirugis 541; mutilus 554; orcellus 551; panuoides 541; paradoxus 280; Pelletieri 280; pinsitus 561; prunulus 550, 551; rhodoxanthus 280*, 283; *rutilus 533; scyphoides 554; Tammii 280*, 282; variabilis 559

Allospori sect. 107, **138**

Amanita 562; rubescens *272*; sp. *250*

Amblystegiaceae 316–318

Amblystegium *excurrens 317*

Amphipleura 170; pellucida 170

Amphora 195–196, *213*; *atomus 184*; ovalis 195; ovalis var. pediculus 195; perpusilla 196

Ananae sect. 107, **122**

Angustiporini subsect. 259, 260, 267

Anomoeoneis *213*, *214*

Anthoceros 62

Aporpiellus subgen. 251, **252**

Arrhenia auriscalpium 555

Ascobolus magnificus 456

Ascophanus granulatus 456

Asterionella 153; formosa 153; Ralfsii 153, *207*, *209*, *212*

Atrotomentosi sect. 538, **540**

Bacillares sect. 176, 181

Bacillaria *phoenocenteron 176; ulna 154; viridis 195*

Bartramiaceae 315

Batrachospermum 68

Biblarium *leptostauron 151*

Blakesleea 324

Boletaceae 101, 223–303, 527, 538

Boletellus 98, 103, 104, 105, 107, **122**–139, 258, 549; sect. **Allospori** 107, **138;** sect. **Ananae** 107, **122,** 139; sect. **Chrysenteroidei** 107, **130,** 139; sect. **Dictyopodes** 107, **136;** sect. **Ixocephali** 107, **135;** sect. **Mirabiles** 107, **128;** sect. **Retispori** 107, **130;** ananas 97, 104, 122, **123**–126, 127, 128, 131, 133, 137, 139; *annamiticus 126*; betula 104, 137, **138;** chrysenteroides 118, 128, 130, 131, **133,** 134; costatus **138; cubensis** 123, **127,** 128; emodensis 122, **126,** 127, 128, *283*; guadelupensis 123; jalapensis 131, **135;** lignatilis 123; *ligulatus 139*; **Linderi** 104, 130, 131, **134; mirabilis 129,** 300; **obscure-coccineus** 123, **127;** *pallescens 123; paradoxus 138;* **pictiformis** 104, 130, **131,** 134; pictiformis var. **fallax** 131, **132,** 133; porphyrius 122, **126,** 127, 128, 131; **projectellus 129,** 130; pustulatus **139;** retisporus 104, **130;** Russellii 98, **136,** 137; singaporensis 104, **135;** *subflavidus 120*; **turbinatus** 130, **134**

Boletineae 97–141, 223–303, 527–567

Boletinellus 243; intermedius 246; merulioides 243, *247; purpureus 249*

Boletinus 98, 100, *225*, *226*, *229*, 250; 251–257, 258; subgen. **Aporpiellus** 251, **252;** subgen. **Eu-Boletinus** 251, **252;** sect. Cavipedes 251, **252,** 253; sect. Palustres 251, **252;** sect. Solidipedes 251, **253,** 257; sect. Spectabiles 251, **252;** amabilis 251, 253, **256,** 257; appendiculatus 257; asiaticus 252; Benoisii 253, 256; *Berkeleyi 254; castanellus 257*, 296; cavipes 251, 252, 255; decipiens 253, **254**, 255, 296; *flavoluteus 257*, *260*, 278; *floridanus 254*; glandulosus 257, 278; grisellus 253, 256; **Lakei** 253, 256, **257;** *merulioides 257*; ochra-

ceoroseus 253, 256, 257; oxydabilis 253, 256; paluster 252; pictus 251, 252, 253, 255, **256;** *porosus* 245, *247*, 249, *257*; porosus var. *opacus 247; punctatipes 257*; solidipes 257; spectabilis 251, 252; *squarrosoides 257, 295*; subgrisellus 257; subtomentosus 296
Boletochaete 225, 300
Boletogaster 103, *122*, 138; *jalapensis 135*; *Russellii 136*
Boletoideae subfam. 227
Boletopsis *corrugata 258; singaporensis 135*
Boletus 224, 225, 228, 230, 240, 243, *257*, 258, 285, 286, 287, 298, 299, 300, 547; subgen. *Porphyrosporus 115;* sect. Favosi 106; *acidus 271*; aeruginascens 259; *alabamensis 293; albidipes* 44, *45*, *272*; alboater 105; *albus 42, 271; amabilis 256; amarellus 46; ananaeceps 123; ananus* 103, 122, *123*, 126; appendiculatus 250; badius 299; *Bellinii 42*; *betula* 103, *138*; bicolor 300; *brachyporus* 243, *249; brasiliensis 298; Braunii 241; brevipes 41*, 44, *265*, 267; *caespitosus 249; castaneus 237*; castaneus fa. *purpurinus 236*; cavipes 251; *chrysenteroides* 103, *133*; chrysenteron 103, 128, **134;** *cinereus 110*; circinans ssp. *leptopus 42; coccineus 123*, 126; communis 134; *costatisporus 115; costatus 138;* crassus 242; *cubensis 127; cyanescens 235*; cyanescens β *fulvidus 237; decipiens* 100, *254*; Earlei 239; edulis 250, 279, 290, 294; *emodensis 126; ferrugineus 297; flavidus 260; flavus 260; floccopus 110*, 113; fraternus 300; Frostii 258; *fulvidus 237*, 299; *fumosipes 116*, 118, 119, 133, 240; *gossypinus 110*; *gracilis* 103, *121*; granulatus 40, 41, 44, 267, 271, 276; granulatus var. *albidipes 272*; *Grevillei 259*; griseus 99, 300; guadelupensis **128,** 131, 133; *gyrosus 249*; *hieroglyphicus 296*; *hirtellus 273, 274*, 276, 277; hirtellus var. *mutans 277*; hirtellus var. *siccipes 274*, 277; *hydriensis 110*; *illudens 287*, 292, *293*, 295; impolitus 300; innixus 299; *intermedius 246*; *isabellinus 123*, 126; jalapensis 103; *Junghuhnii 297*; *lacteus 235*; *lacunosus 122, 139*; *Lakei 257*; *lanatus 296*; *lateralis 247*; *Leguei 296; lepiota 110*; lignatilis **127;** *lignicola 299*; lividus 243, 249; lividus ssp. *alneti 249*; lividus ssp. *labyrinthicus 249*; lividus var. *rubescens 249*; luridellus 100; *luteus 258*, 264, *270*; ***Morganii 138***; ***Murraii 256***; *nebulosus 115*, 116; nigrellus 105; *obscure-coccineus 127*; pallescens 126; *pictus 256*; ***Pierrhuguesii 46***; ***piperatus 46***; ***placidus 42, 271***; ***porphyrosporus*** 106, *115*; porphyrosporus var. minor 116; *projectellus* 103, *129*; *pseudogranulatus* 44, *265, 268; pseudoscaber 115*; pulverulentus 250, 300; *punctipes 277*; *pustulatus 139*; *retisporus 130*; Rostrupii **139;** Roxanae 299; rubellus 99, 127, 250; rubellus ssp. caribaeus 100; *rubescens 249*; rubinellus 45–47; rubricitrinus 99; *rubrotubifer 46*; *rufocastaneus 237*, 239; ***Russellii*** 103, *136*; scaber 99; *sistotrema* 243, *249*; sordidus 103, 118, **119;** spadiceus 297; *sphaerosporus 243*; ***Spraguei 256***; squamatus 127, **128;** *squarrosus 110*; *strobilaceus* 106, *110*; *strobiloides 110*; *stygius 110*; *subluteus 269; subtomentosus* 128, *296*; subtomentosus ssp. spadiceus 297; subtomentosus ssp. spadiceus var. *lanatus 297*; subtomentosus var. *Leguei 296*; sudanicus 241; sulphureus 300; testaceus 237; *tomentosus 277*, 296; *tridentinus 260*; *tristis* 115, *118*; *tropicus 241*, 242; *tumidus 300*; *umbrosus 115*; Vanderbiltianus 46; variegatus 236; versicolor 127; *viscosus 265*, 267
Bornetia *Binderiana 442*
Bovini sect. 259, 278
Brachytheciaceae 318
Brachythecium arenarium 318; collinum 318; **longidecurrens 318; micro-collinum 318;** rivulare 318
Brasiliensis sect. 287, **298**
Breutelia **angustiretis 315;** chrysura 315; integrifolia 315
Brevistriatae subgen. 187, 188
Bryaceae 312–315
Bryum andicola 315; **austro-chilense 313; brachycarpum 314;** caespiticum 314; **dicarpum 313; fuegianum 313;** Hatcheri 314; Lechleri 315; **macrosporum 313;** obscurum 313; **pauperculum 314; pseudothyridium 314; Roivainenii 312;** vernicosum 314; zeballosicum 314
Calliergidium **austro-stramineum 317**
Calliergon sarmentosum 318
Calliergonella complanata 319
Caloneis 172, 194; **Lewisii 172;** Schumanniana 172; silicula var. alpina 172; *trinodis 172*

Calyculosphaeria calyculus 466
Camptochaete sect. **Rigodiella 316; arbusculans 316**
Candida 375; pulcherrima 348, 372; tropicalis 348, 372
Candidaceae 375
Cantharellus 544; subgen. *Hygrophoropsis 544*; *albidus 547*; *aurantiacus* 544, *545*; *Dutrochetii 541*; *olivaceus 541*; *Ravenelii 545*, 546
Capitatae subgen. 187, 189
Catacauma **Sabal 461**
Catagonium 318
Cavipedes sect. 251, **252,** 253
Centroceras clavulatum 440
Ceramiaceae 439–453
Ceramiales 442
Ceriomyces *alabamensis 293*, 295; *betula 138*; *flavimarginatus 293*; *fumosipes 116*; *Housei 296*; *illudens 293*; *jalapensis 135; mirabilis* 128, *129; projectellus 129*; *pseudoboletinus 290*, 292; *Russellii 136; sordidus 119*
Chalciporus 47; *piperatus 46*
Champia sp. 442
Chanterel *alectorolophoides 545*
Chara 305; Curtisii 306; delicatula 306; foetida 305, 306; hydropitys 306; **leiopitys 306;** leptopitys 306; Martiana 305, 306; vulgaris 208
Choanephora 324, 336; cucurbitarum 336
Chorisodontium lanigerum 309; **sericeum 309**
Chroogomphus subgen. 527, 528, 529
Chrysenteroidei sect. 107, **130,** 139
Ciboria Armeriae 436; *Juncigena* 425, *432*, 433
Cladopodiella fluitans 209
Claudopus 50, 51; byssisedus 51
Clavariineae 562
Claviceps *caricina 397*, 401; nigricans 394, 396
Clitocybe 544, 550; *aurantiaca 545*, 546; *Pelletieri 280*
Clitopilopsis 561; pallida 561
Clitopilus 50, 98, 544, 548, 549, **550**–561; sect. **Pleurotelloides** 551, **557;** sect. **Prunuli** 550, **551;** sect. **Scyphoides** 550, **553,** 560; *abortivus 561*; *albogriseus 561*; cancrinus 561; cretaceus 552; cretatus 561; crispus 549, 550, 560; Giovanellae 99, 550, **553,** 554; *omphaliformis 554*; omphaliformis fa. *calathinoides 555*; orcelloides 550, 560; *orcellus 551*, 552; pallidus 561; Passeckerianus 550, 551, 560; pinsitus 558, 560, 561; **pleurotelloides** 551, 557, **558,** 559, 560, 561; prunulus 544, 548, 549, 550, **551; scyphoides** 550, **554,** 561; scyphoides var. **floridanus** 99, 554, **555,** 556, 560; scyphoides var. **submicropus 556;** scyphoides var. typicus fa. **mutilus 555,** 560, 561; scyphoides var. typicus fa. typicus 553, **554;** *submicropus 554*; togoensis 561; undatus 561; *variabilis 558*; **venososulcatus** 551, **557**
Clitopilus trib. *550*
Cocconeis 165–166; *aspera 197*; *lineata 165*; placentula 165, 207, 208, 209; placentula var. lineata 165, 211, 212
Cocconema *cistula 197*; *tumidum 198*
Coelopus 231
Colletonema *vulgaris 171*
Complexae subgen. 187, 194
Compsopogon 61
Conferva *flocculosa 149*; *pectinalis 160*
Cookeina sulcipes 455, 456, 457; tricholoma 455, 456, 457
Cordyceps militaris 458
Coriolus 527
Cortinaria *rutila 533*
Crepidotus 538, 544; *croceolamellatus 541*; **reniformis 544;** versutus 544
Cricunopus 257; *luteus* 257, *270*
Criella leucothoës 458
Cryptococcus hominis 347, 348, 375
Cunninghamella 321–343; *africana* 323, 324, *326*, 327; albida 323, **334;** Bainieri 323, 324, 326, **328,** 334, 335, 336; Bertholletiae 323, 324, 326, 329, **330,** 331 332, 333, 334; Blakesleeana 323, 324, 326, **329,** 330, 334; dalmatica 323, **335,** 336; *echinata* 323, *329*, 330; echinulata 323, 324, 325, **326,** 327, 328, 329, 330, 332, 334; elegans 323, 324, 326, 330, 331, **332,** 333, 334, 335; *mandshurica 336*; microspora 323, **336;** polymorpha 323, **335**, 336; ramosa 323, 324, **335;** *verticillata* 323, 327, *329*, 330; sp. *"A" 329*
Cyclotella 147–148; comta var. radiosa 147, 207; Meneghiniana var. rectangulata 147, 148; Meneghiniana var. *stelligera 148*; stelligera 147, 148
Cylindrosporium **Securidacae 469**
Cymbella 196–199, 213; amphicephala 196, 197; aspera 196, 197, 208; cistula 196, 197; cuspidata 196, 197; Ehrenbergii 196, 197; gracilis 209; Hauckii 196, 197; microcephala 196, 197; naviculiformis 196, 198; *pediculus 195*;

scotica 196, 198, 208, 209; sinuata 196, 198; tumida 196, 198; turgida 196, 198; ventricosa 196, 198, 208, 211
Cyphellineae 547, 562
Cystogomphus 528, 529; Humblotii 529
Cystopleura 202, 214; turgida 202; Zebra var. proboscidea 202; Zebra var. saxonica 202
Cystopus 91

Daedalea *merulioides 247*
Debaryomyces 375; hominis 348
Decipientes sect. 176, 187
Decussatae sect. 176, 177
Delesseria 24; sinuosa 64
Dendroligotrichum squamosum 319
Denticula *Tabellaria 203*
Desmogonium 164
Diadesmis *biceps 182*
Diatoma *fenestratum 148*
Dicranaceae 309
Dictyochorella *Andropogonis 468*
Dictyopodes sect. 107, **136**
Dictyosphaeria 440
Dictyota sp. 442, 443
Didymodon **ampliretis 310;** diaphanobasis 310
Didymosphaeria 467; **Trichostigmae 467**
Diploneis 174, 213; ovalis 174; Smithii 174
Distantes subgen. 187, 188
Divergentes subgen. 187, 192
Dochmiopus 550, 559
Dodgea 255
Dothideales 459–465
Dothidella **domingensis 459;** tinctoria 459
Drepanocladus 318; exannulatus 208

Eccilia 50, 51, 548
Echinella *circulare 149*
Entoleiae 176, 182
Entoloma 50, 51; rhodopolium 51
Epidocium *affine* 394, 396, *397*, 399, 401, 423; *ambiens 391*, 394, 395, 396, 401; ambiens fa. Caricis-paniculatae 394; arabicus 395
Epithemia 202; proboscidea 202; saxonica 202
Erinella calospora 456, 457; longispora 456, 457
Eriocorys 108; strobilacea 106, *110*; strobilacea var. *floccopus 110*
Eu-Boletinus subgen. 251, **252**
Eucatagonium politum 319
Eunotia 155–165, 210, 213; alpina 160; *amphioxys 203*; arcus var. curta 156, 157; arcus var. *tenella 164*; *bidens 162*; diodon 157; elegans 155, 157; exigua 156, 157; faba 157, 158; fallax 156, 158; flexuosa 155, 158, 163, 210; formica 155, 158; gracilis 156, 158; *impressa 161*; incisa 164; indica 156, 158; lunaris 156, 159, 210, 211; lunaris var. capitata 156, 159; Meisteri 156, 159, 207, 212; microcephala 157, 159, 208, 212; monodon 156, 160; monodon var. major 155, 160, 208, 210; Naegelii 156, 160, 208, 209, 212; pectinalis 156, 160, 207, 210, 211; pectinalis var. minor 160, 207; pectinalis var. minor fa. impressa 161; pectinalis var. recta **161;** pectinalis var. undulata 161, 210, 211; praerupta 156, 162; praerupta var. bidens 157, 162; praerupta var. curta 162; praerupta var. inflata 162; robusta 157, 162, 207, 208, 212; rostellata 156, **163;** septena 157, 163; septentrionalis 156, 163, 210; sudetica 156, 163; suecica 157, 163; tautonensis 155, **163,** 207, 213; tenella 156, 164, 210; tridentula 159; tridentula var. perminuta 159; trinacria 156, 164; valida 156, 164; veneris 157, 164, 165, 208, 209, 211
Euryporini subsect. 259, 278
Euryporus 251; cavipes 251
Exilaria *Vaucheriae 152*

Falkenbergia rufalanosa 440
Favolus *purpureus 249*
Favosi sect. 106
Filoboletus 562
Fimetariales 465
Fistulina 562
Fistulinaceae 562
Fistulinella 562
Flammula *rhodoxanthus 280; Tammii 280*
Flammulina velutipes 264
Floccigomphus sect. 528, 529
Fragilaria 150–153; bicapitata 150, 210, 212; brevistriata 150, 151; capucina var. mesolepta 150, 151; constricta 152; construens 150, 151; crotonensis 150, 151, 211; elliptica 150, 151, 210; grandis 161; leptostauron 150, 151; *mesodon 148;* pectinalis var. *undulata 161*; pinnata 150, 151; undata 152; undata var. **lobata** 150, **151;** undata var. γ 152; Vaucheriae 150, 152; vires-

cens 150, 152, 207, 210, 211, 212; virescens var. capitata 152
Frostiella 103, *122*, 137; *betula 138; Russellii 136*
Frustulia 170; bipunctata 192; *cuspidata 177; lanceolata 180; maior 194; ovalis 195; pellucida 170;* rhomboides var. *saxonica 171;* rhomboides var. saxonica fa. *capitata 171*
Fucus 62, 91; evanescens 68
Funaria chiloensis 312; **pungens 311**
Funariaceae 311–312
Fungi Imperfecti 468–469

Gaillonella *italica 147*
Ganoderma 102, 121
Gastroboletus 225, 226
Genuini sect. 106, **108**
Geopetalum *viticola 558*, 559
Gigartina compressa 24
Gomphidiaceae 102, **527**–537
Gomphidius 98, 100, 528, 529–537, 548; subgen. Chroogomphus 527, 528, 529; subgen. Laricogomphus 528, 536; subgen. Myxogomphus 528, 536; sect. Floccigomphus 528, 529; sect. Macrosporus 528, 536; Microsporus 528, 537; sect. Viscogomphus 528, 529; *alabamensis 533, 535*, 536; *alachuanus 531*, 533, 536; *foliiporus 280*, 282, *537;* furcatus 533, 536; glutinosus 529, 530, 532, 536; *jamaicensis 531*, 533, 535; leptocystis 529; *litigiosus 533;* maculatus 529, 530, 536; nigricans 536; ochraceus 531, 533, 534, 536; oregonensis 537; *rhodoxanthus 280, 537;* roseus 530, 537; rutilus 529, 530, 531, **533,** 536; rutilus ssp. **alabamensis** 531, **535,** 543; rutilus ssp. typicus 533, 534; rutilus var. fulmineus 534; rutilus var. **litigiosus 534;** rutilus var. pulcher 534; rutilus var. testaceus 534; septentrionalis 536; sibiricus 529; Smithii 536; subroseus 537; *superiorensis* 533, *536; testaceus 533;* tomentosus 527, 529, 533; vinicolor 529, 530, 533, 536; vinicolor ssp. **jamaicensis 531;** *viscidus* 531, *533*, 536; viscidus var. fulmineus 534; viscidus var. testaceus 534; viscidus fa. *columbiana 533*, 534, 536; viscidus fa. testacea 534; sp. 536
Gomphonema 199–202, 213; acuminatum 199; acuminatum var. coronatum 199; acuminatum var. laticeps 200; acuminatum var. pusillum 200; angustatum var. obtusatum 199, 200; augur 199, 200, 208; *auritum 201; capitatum 200*; constrictum 199, 200; constrictum var. capitatum 200; *coronatum 199;* gracile 199, 200; gracile var. auritum 201; gracile var. lanceolata 201; gracile var. naviculoides 201, 211; *laticeps 200; micropus 202; naviculoides 201;* parvulum 199, 201, 207, 211, 212; parvulum var. micropus 202, 211; sphaerophorum 199, 202; turris 199, 202
Gomphus *pezizoides 541*
Gonatobotrys *microspora 336*
Gracilaria 24
Graciles sect. 107, **119**
Granulati sect. 258, 259, 260
Griffithsia 439–453; Binderiana 439, 440, **442,** 443; corallina 440, 442, 443; corallinoides 440; globulifera 441; Metcalfii 439, **440,** 441, 442, 443; ovalis 439, **440;** rhizophora 439, 440, 441, **443,** 444; subcylindrica 443; tenuis 439, 440, **441,** 442, 443; *thyrsigera* 439, *441; sp. 441*
Grimmia apocarpa 311; **scabripes 310**
Grimmiaceae 310–311
Grunowiae sect. 203
Guepinia lutea 79; merulina 79
Gymnocybe *Tammii 280*
Gymnogomphus 531, 562
Gymnosporangium clavariaeforme 480; *clavipes* 476, *481*, 500, 512, 513; *conicum* 475, 476, *481;* effusum 481, 498; globosum 476, 483, 512; Juniperi 475; juniperinum 475; Juniperi-virginianae 512; *juvenescens* 475, 478, 479, 480, *481*, 485, 488, 490, 491, 492, 493, 495, 500, 501, 502, 504, 511, 514; Nelsoni 478, 479; nidus-avis 475–**481**–525; Sabinae 481
Gyrodon 225, 226, 229, 230, 243–250, 527, 537, 538; subgen. *Paragyrodon 242; caespitosus 249; capensis 250; castanellus 250; Emilei 250; filiae 250; fusipes 250; immutabilis 250;* intermedius 244, **246,** 284; Ledermannii 250; lividus 243, 244, **249;** lividus ssp. *alneti 249;* lividus ssp. *labyrinthicus 249;* merulioides 244, 245, 246, **247,** 248, 249, 255, 257, 284; *Mikhnoi 249; miramar 250; Mougeotii 250; Oudemansii 250; placidus 250;* **proximus 244**, 246, 247; purpureus **249;** Rompelii 244, 245, 246, **247,** 249, 284; *rubellus 250; rubrescens 249;* sistotrema 243; *sistotremoides* 243, *249; volvatus 250;* sp. 244, 249

Gyrodonteae trib. 230, 231
Gyrodontoideae subfam. 226, **230**
Gyroporoideae 223–303
Gyroporus 225, 226, 229, 230, 231–240; albisulphureus 240; asprellus 239; atroviolaceus 232, **239;** bisporus 240; caespitosus 239; castaneus 231, 232, 233, **237,** 299; castaneus var. *fulvidus 237;* cyanescens 231, 232, 234, **235,** 236; cyanescens var. *lacteus 235;* deflexus 239; Earlei 239; *fumosiceps 240;* jamaicensis **240;** *lacteus 235;* lividus 243; *pisciodorus 240; porphyrosporus 115, 239;* praeanisatus 240; **purpurinus** 232, **236,** 237, 238; *Rhoadsiae 240; roseialbus 232,* 233, 234, 235; rufus 239; scaber 239; *stramineus 240;* **subalbellus 232,** 233, 234; umbrinisquamosus 231, **234,** 235

Halimeda sp. 440, 443
Hantzschia 203; amphioxys 203; elongata 203
Haplotrichum *albidum 334*
Heterostichae sect. 176, 184
Hexajuga 550; prunulus 551, 552
Himantidium arcus var. *curtum 157;* bidens 162; *exiguum 157; gracile 158; majus 160; minus 160; veneris 164*
Hirtellini subsect. 259, **273**
Hookeriaceae 316
Hygroamblystegium 316–317; filum 317; filum var. **compactum 317;** fuegianum 317; fuegianum var. **excurrens 317;** fuegianum var. **gracilis 317;** fuegianum var. **secundum 317;** fuegianum var. **Skottsbergii 317**
Hygrocybe 49
Hygrophoropsis 100, 539, **544**–547; albida **547;** aurantiaca 539, 544, **545;** aurantiaca var. **nana 546;** aurantiaca var. typica **545; tapinia** 539, **544,** 545
Hygrophoropsis subgen. *544*
Hymenoscypha *Curreyana 428; Duriaeana 391*
Hypnum 559; *austro-stramineum 317;* leucocytus 319
Hypomyces 358
Hypochnus 39
Hypocrea citrina 459; patella 459; rufa 459
Hypocreales 458–459

Involuti sect. 539, **543**
Ixechinus 223, 225
Ixocephali sect. 107, **135**
Ixocomus 40, 225, 253, *258;* sect. *Piperati 47;* sect. *Pseudotsugini 257; Bellinii 42; cembrae 277; flavus 260; granulatus 42; hirtellus 274; Lakei 257; luteus* 258, *270; piperatus 46; punctipes 277; sibiricus 260*

Jugasporaceae 102, 527, 544, 547–562

Krombholzia 262; *porphyrospora 115*

Lactarius sect. Plinthogali 48; acer 48; azonites 48; fuligineus 48; lignyotus 48; nigroviolascens 47–48
Lamprothamnus 305
Lanceolatae sect. 203
Laricogomphus subgen. 528, 536
Larigni sect. 259
Lasiosphaeria pezizula 466
Latiporini subsect. 259, 260
Laurencia 440
Leccinum 99, 104, 225, 228, 229, 239, 262; chalybaeum 99, 258; *constrictum 235;* rubropunctum 258
Lemanea 68
Lembophyllaceae 316
Lenzites 527
Leptonia 50
Leptoporini subsect. 259
Leptosphaeria **Cecropiae 466; Smilacis 466**
Leptotaceae 547
Leptotus 547
Leskea *nitida 318*
Leucobolites 231
Leucoconius 231
Leucogyroporus deflexus 239
Leucoporelleae trib. 230, 231
Liagora sp. 442
Lineolatae sect. 176, 177
Linospora Trichostigmae 467

Macromitrium **coriaceum 315;** macrosporum 316; Rusbyanum 316
Macrosporus sect. 528, 536
Maiores subgen. 187, 193
Megalodonta Beckii 207
Megaporini subsect. 259
Melampsoraceae 488
Melanomphalia 562
Melanopsamma **Milleri 465**
Melosira 146–147; ambigua 146; italica 146, 147, 210; roeseana 146, 147; roeseana var. epidendron 147, 211, 212; varians 146, 147
Meridion 149–150; circulare 149, 210,

211; circulare var. constricta 150, 211; *constrictum 150*
Merulius 537, *544; aurantiacus 545*
Mesoleiae sect. 176, 184
Mesotrema 440
Metasphaeria phyllachoracearum 467; sp. 468
Microdictyon Setchellianum 442
Microneis subgen. 166
Microsporus sect. 528, 537
Mielichhoferia leptoclada 312; **multiflora 312**
Minusculae sect. 176, 183
Mirabilis sect. 107, **128**
Molendoa andina 310; boliviana 310; **fuegiana 309,** 310; Herzogii 310
Mouceron trib. *550*
Muratella 323, *325; elegans* 323, 324, 327, *328; sp. 328*
Myrioconium *ambiens 391*, 395, 396; *Scirpi 413; Scirpicola 413; tenellum 428*
Myxocollybia velutipes 264
Myxogomphus subgen. 528, 536

Navicula 170, 176–187, 209, 213; sect. Bacillares 176, 181; sect. Decipientes 176, 187; sect. Decussatae 176, 177; sect. Entoleiae 176, 182; sect. Heterostichae 176, 184; sect. Lineolatae 176, 177; sect. Mesoleiae 176, 184; sect. Minusculae 176, 183; sect. Orthostichae 176, 177; *affinis 173;* americana 181; *amphigomphus 174; amphirhynchus 173; ampliata 174;* anglica 178; *angusta 178;* atomoides 185; atomus 183, 184; bacilliformis 185; bacillum 182; *bisulcata 173; Brebissonii 192;* capitata 180; cincta 177, 178; cincta var. angusta 178; cocconeiformis 184; **concava 182,** 183; contenta var. biceps 182; *crassinervia 171;* cryptocephala 177, 178; cryptocephala var. pumila 177, 179; cryptocephala var. veneta 177, 179; cuspidata 177; decussis 178, 179; dicephala 178, 179; essox 193; exigua var. **capitata** 178, **179;** *fasciata 189;* festiva 183, 184, 210, 212; Flotowii 183; *gentilis 194; gibba 202;* globulifera 177, 180; halophila var. minor 187; hassiaca 182; hungarica var. capitata 177, 180; *iridis 173;* **Keeleyi** 182, **183,** 211, 212; lanceolata 178, 180; mesolepta var. *stauroneiformis 190;* minima var. atomoides 185, 207, 210, 211; muralis 183, 184; mutica 185; nodosa 188; perpusilla 182, 183, 211, 212; placenta 177; placentula 211; **poconoensis** 182, **183;** pseudoscutiformis 184; pupula 185; pupula var. bacillaroides 186; pupula var. capitata 186; pupula var. rectangularis 186; quadripartita 178, 180, 212; radiosa 178, 180, 208; radiosa var. tenella 177, 181, 208, 209, 211; *rhomboides 170;* rhomboides var. *amphipleuroides 170;* rhynchocephala 178, 181; Roteana 185, 186, 207, 212; scutiformis 184; semen 187; *Smithii 174; stomatophora 192;* subatomoides 185, **186,** 207, 212; *sublinearis 189; tenella 181;* Thingvallae 179; *transversa 194;* trinodis 172; Trochus var. biconstricta 172; *turgida 202;* variostriata 185, 186; *veneta 179;* viridula var. linearis 178, **181;** vitrea 184
Neidium 173–174, 213; affine 173; affine var. amphirhynchus 173; bisulcatum 173; bisulcatum var. undulatum 173; iridis 173; iridis var. amphigomphus 173, 174; iridis var. ampliatum 173, 174; iridis var. vernalis 173, 174
Nemalion 63
Nitella 305; flexilis 208
Nitzschia 203–204, 213, 214; sect. Grunowiae 203; sect. Lanceolatae 203; sect. Nitzschiellae 203, 204; acicularis 204; amphibia 203, 204; elongata 203; Hantzschiana 203, 204, 211; Hantzschiana fa. subserians 204, 211, 212; palea 203, 204, 210, 212; palea var. debilis 204, 210, 212; palea var. tenuirostris 204; sinuata var. Tabellaria 203, 209; vivax var. *elongata 203*
Nitzschiellae sect. 203, 204
Nolanea 50
Nostoc 62
Nymanomyces **Xolismae 458**

Octojuga 549, *550; Fayodi 558; Passeckeriana 560; pleurotelloides 558; variabilis 558*
Odontidium 148; anceps 148, 211; hiemale var. mesodon 148, 210, 211
Oedocephalum *albidum 334; echinulatum* 323, *326*, 327
Omphalia 550; *Giovanellae* 549; *553; scyphoides* 549, *554*
Omphalina *floridana 554*, 556; *scyphoides 554*
Orthostichae 176, 177
Orthotrichaeceae 315–316

Padina sp. 442, 443
Palustres sect. 251, **252**
Panuoides sect. 538, **540**
Paragyrodon 226, 230, 242–243; sphaerosporus 242
Paragyrodon subgen. *242*
Parallelestriatae subgen. 187, 188
Parasitici sect. 287, 297
Patella coprinaria 456, 457; theleboides 456, 457
Paxillaceae 102, 527, 537–547, 549
Paxillopsis 539, 548; *prunulus 551*
Paxillus 98, 100, 527, 538, **539**, 540, 544, 548; sect. **Atrotomentosi** 538, **540**; sect. **Involuti** 539, **543**; sect. **Panuoides** 538, **540**; *acheruntius 541;* argentinus 537, 543; atrotomentosus 538, 540; aurantiacus 545; *corrugatus 543;* Curtisii 539, 541, 543, 544, 545; Fagi 545; *flavidus 280*, 544; *infundibuliformis 284;* involutus 538, 539, 540, 543, 548, 550; *ionipus 541; lamellirugus 541;* lateritius 543; *ligneus 541;* miniatus 543; panuoides 538, 539, 540, **541**, 543, 544; *paradoxus 280*, 544; *Pelletieri 280*, 544; *pinguis 280*, 543; polychrous 538, 540; *porosus 247; prunulus* 544, *551;* prunulus var. *orcella 551; pubescens 533, 535*, 536, 543; *reniformis 544; rhodoxanthus 280*, 544; *rudis 541;* russuloides 543; *sulcatus 280*, 283; sulphureus 544; *Tammii 280*, 544
Peziza ciborioides 427; *Curreyana* 423, *427*, 429, 431; *Curreyi 427; Duriaeana 391*, 394 395, 399; Friesii 427; *juncifida 428*, 431; tuberosa 417
Pezizales 455–457
Phacidiales 458
Phaeogyroporus 225, 226, 231, 240–242; Braunii 240, **241**, 242; tropicus **241**, 242
Phaeoporus 105, *115; porphyrosporus* 106, *115;* pseudoscaber 106
Phaeotrabutia **Smilacis 460;** sp. 461
Phialea *Curreyana 427*
Phillipsia domingensis 455, 456
Philonotis acicularis 315; **luteola 315;** parallela 315; vagans 315; varians 315
Phlebopus 225, 228, 229, 258; capensis 250; sulphureus 250, 300
Phyllachora Acaciae 461, 463; Bourreriae 461; **Exostemae 462;** gratissima 462; insueta 462; Masini 463; **ocoensis 463;** Ocoteicola 463; panamensis 464; Paspalicola 464; Phaseoli 464; Roureae 464; Scleriae 464; viequesensis 464
Phyllobolites 107, 139, 543
Phylloporus 97, 223, 224, 225, 227, 229, 257, 279–284, 285, 286, 287, 291, 293, 295, 296, 298, 538, 544; *bogoriensis 280;* **infundibuliformis 284;** *intermedius 246, 284; lariceti 250*, 251, *284; malaccensis 121, 284; paradoxus 280*, 284; Pelletieri 279; rhodoxanthus 244, 251, **280**, 282, 283, 284, 296, 537, 544; rhodoxanthus ssp. americanus 280, 282, **283**, 284; rhodoxanthus ssp. **bogoriensis** 280, **282**, 284; rhodoxanthus ssp. europaeus 279, 280, 282, **284;** rhodoxanthus ssp. foliiporus **280**, 281, 282, 537; *Rompelii 247, 284; squarrosoides 284, 295; sulcatus 280*
Phyllosticta **Citharexyli 468; Stigmatophylli 469**
Physalospora Phaseoli 464
Pinnularia 187–195, 210, 213; subgen. Brevistriatae 187, 188; subgen. Capitatae 187, 189; subgen. Complexae 187, 194; subgen. Distantes 187, 188; subgen. Divergentes 187, 192; subgen. Maiores 187, 193; subgen. Parallelestriatae 187, 188; subgen. Tabellariae 187, 191; acrosphaeria 188; acrosphaeria var. turgidula 188; *amphicephala 189;* borealis 188; Braunii var. amphicephala 189, 190; Brebissonii 192; brevicostata 188; **Burkei 189;** *capitata 180; cincta 178;* **Clevii 193;** commutata 195; divergens 192, 193; divergens var. parallela 193; essox 193; fasciata 188; gentilis 194; gibba 191; gibba var. **rostrata 192;** Hilseana 189, 190, 209, 212; interrupta 189, 190; legumen 192, 193; maior 194; maior var. transversa 194; mesolepta var. stauroneiformis 189, 190; nobilis 194; nodosa 188; obscura 192, 193, 210, 212; *ovalis 174;* parallela var. *divergens 193;* stomatophora 191, 192; streptoraphe 194; subcapitata 189, 190; subcapitata var. paucistriata 189, 191; subcapitata var. stauroneiformis 189, 190, 191; sublinearis 189; substomatophora 192; *sudetica 195;* viridis 194, 195; viridis var. elliptica 195; viridis var. fallax 195; viridis var. sudetica 195, 207
Pinuzza 257; flava 257
Piperati sect. *47*, 259, **278**
Piptocephalis 323

Placosphaeria *Junci 428*, 429, 431
Plagiotheciaceae 318–319
Plagiothecium **nitidum 318**
Pleospora Doidgeae 468
Pleuropus *minimus 554*, 556; *obesus 551*, 552; *prunulus 551*
Pleurotelloides sect. 551, **557**
Pleurotellus *Passeckerianus 560*
Pleurotus *mutilus 554*, 561; *Passeckerianus 560; viticolus 558*
Plicaturella 539
Plinthogali sect. 48
Polyporoletus 562
Polyporus **Maxonii 279**
Polytrichaeceae 319
Polytrichum commune 319
Porphyra 24
Porphyrellus 98, 103, 105, 106, 113, **115**–122, 527; sect. **Graciles** 107, **119;** sect. **Tristes** 107, **115;** *alboater 122;* **Cookei 122; gracilis** 104, 113, 120, **121;** *indecisus 122;* lacunosus 121, 131; **malaccensis** 104, 120, **121,** 131, 284; *nigrellus 122; porphyrosporus 115;* **pseudoscaber** 103, 104, 105, 106, **115,** 119, 121, 133, 239; pseudoscaber ssp. **cyaneocinctus 116,** 119, 123; **subflavidus** 99, 104, **120,** 122, 131; **tristis** 104, **118**
Porphyrospori 106
Porphyrosporus subgen. *115;* subflavidus 104
Prachtflorella microspora 336
Prunuli sect. 550, **551**
Psathyra 118
Psathyrella 118
Pseudoboleti sect. 287, **299**
Pseudoleskia 316; fuegiana var. *gracilis 317;* fuegiana var. *Skottsbergii 317*
Pseudophyllopori sect. **287,** 296
Pseudotsugini sect. 257
Psiloboletinus 226, **250**–251, 284; **lariceti 250**
Pterospori sect. 106, **114**
Ptilota serrata 64
Puccinia Helianthi 486; *nidus-avis 481*
Pulveroboletus 97, 225, 228, 229, 230, 240, 258; auriporus 300; corrugatus 258; gentilis 300; retipes 230

Retispori sect. 107, **130**
Rhacomitrium crispulum 311; **limbatum 311;** ptychophyllum 311; **scabrifolium 311**
Rhagadolobium cucurbitacearum 465
Rhodocybe 527, 548, 549; alutacea 548; fallax 549; **truncata** ssp. **subvermicularis 548**
Rhodogoniosporaceae 527, 549
Rhodopaxillus 548; *fallax 549; truncatus* var. *subvermicularis 548*
Rhodophyceae 439–453
Rhodophyllus 50, 51, 527, 548, 549, 561; abortivus 561; albogriseus 561; **Farlowii 49**–51; salmoneus 50; *prunulus 551*
Rhopalodia 202–203, 214; gibba 202
Rhymovis 539, 540; *panuoides 541*
Rhymoxis 540
Rigodiella sect. **316**
Ripartites 538
Roestelia 476; cornuta 476; *lacerata γ 476; Nelsoni 479; nidus-avis 481*
Rosellinia sp. 465
Rostkovites 257, 258; californica 277, 278; granulatus 257; *hirtellus 274*
Ruthea 539
Rutstroemia 436; *Curreyana 427*

Saccharomyces pulcherrimus 366; pulcherrimus secundarius 366
Saccobolus Kervernii 456, 457
Saitomyces 325; japonicus 334
Sargassum echinocarpum 442; sp. 440, 443
Sauloma tenella 316
Schistidium sect. 311
Scleroderma 224, 298
Sclerotinia 385–437; Aschersoniana **435,** 436; Caricina **436;** Caricis-ampullaceae 387, 389, 405, **407;** Curreyana 387, 423, 425, **427,** 429, 431, 432, 433, 434, 435; Duriaeana 386, 389, **391,** 394, 395, 396, 399, 401, 403, 408, 411, 421, 423, 425, 427, 432, 433; *Duriaeana "ambiens form" 397;* Gladioli 420; heterocarpa **436; Juncigena** 387, **432,** 433, 435; longisclerotialis 387, 388, 389, 401, **403,** 405, 417; **Luzulae** 387, 433, **434;** paludosa **436; Schoenicola** 387, 423, **425;** Scirpicola 387, **413,** 417, 418, 420, 421, 423, 425, 428, 431, 432; sclerotiorum 386; sulcata 387, 389, 394, 395, 396, **397,** 399, 401, 403, 420, 421, 423, 425, 432, 433; utriculorum **435;** Vahliana 387, 408, **409,** 411, 412, 413, 435; Vesicariae **436**
Sclerotiniaceae 385
Sclerotium Kneiffii 423; Luzulae 434; *nigricans 391*, 394, 395; *roseum 413*, 417, 423, 431, 435; *sulcatum* 394, *397*, 399, 401, 423, 424

Scutigeraceae 562
Scyphoides sect. 550, **553,** 560
Secotium *excavatum 123,* 126
Sematophyllaceae 319
Sematophyllum **aureo-nitidum 319;** callidum 319
Sigmoideomyces 324
Solidipedes sect. 251, **253,** 257
Sordaria curvula 465
Spectabiles sect. 251, **252**
Sphacelia *ambiens 391,* 394; *Curreyana 428; nigricans 391,* 395; *Scirpicola 413; tenella 427,* 431
Sphaeria *calyculus 466; pezizula 466*
Sphaeriales 465–468
Sphaerostilbe *hypocreoides 459; intermedia 459*
Sphenella *obtusata 200; parvula 201*
Sphenosira *epidendron 147*
Splachnaceae 312
Stauroneis 174–176; *amphicephala 175;* anceps 174, 175; anceps var. amphicephala 175; anceps var. gracilis 175; anceps var. linearis 175; *gracilis 175;* **Kriegerii** 174, **175;** *linearis 175;* phoenicenteron 174, 176, 210; *pygmaea 175; Roteana 186;* Smithii 174, 176
Stauroptera gibba 191
Staurosira *construens 151*
Stegastroma 467
Stenoporini subsect. 259, 278
Stenopterobia 204–205; intermedia 204
Stilbocrea hypocreoides 459
Strobilomyces 98, 103, 104, 105, 106, 108–115, 258, 527; sect. **Genuini** 106, **108;** sect. **Pterospori** 106, **114;** *ananaeceps 123; annamiticus 126; coccineus 123,* 125; **confusus 108,** 113, 114; costatisporus 104, **115;** echinatus **114;** *excavatus 123;* fasciculatus **139;** floccopus 103, 104, 106, 108, 109, **110,** 112, 113, 114, 130; indicus 113; lepidellus 115; ligulatus **139;** montosus **114;** nigricans 108, 113, **114;** *pallescens* 97, *123,* 125, *139;* paradoxus **138;** polypyramis 114; *porphyrius 126;* **pterosporus** 104, **114,** 115; rufescens **139;** *strobilaceus* 106, *110,* 112, 113; velutipes 105, 106, 108, **113,** 119
Strobilomycetaceae 97–141, 538
Subtomentosi sect. 287, **297**
Suillellus *pictiformis 131*
Suilloideae 226, **250,** 251
Suillus 98, 225, 227, 229, 230, *231,* 250, 253, 257–279, 299; sect. Bovini 259, **278;** sect. Granulati 258, 259, 260; sect. Larigni 259; sect. Piperati 47, 259, **278;** subsect. Angustiporini 259, 260, 267; subsect. Euryporini 259, 278; subsect. **Hirtellini** 259, **273;** subsect. Latiporini 259, 260; subsect. Leptoporini 259; subsect. Megaporini 259; subsect. Stenoporini 259, 278; **acidus 271;** aeruginascens 259; **albidipes 45,** 261, 267, **272;** americanus 260; *atroviolaceus* 239, *279;* australis 98; Bellinii 267; bovinus 243, 278; *Braunii 241;* **brevipes 41,** 44, 45, 259, 261, **265,** 267, 271, 272, 273; brevipes var. **aestivalis 267,** 271; brevipes var. **pseudogranulatus 268,** 269; brevipes var. typicus **265,** 268; *cantharelloides 279; castaneus* 237, *278;* **cembrae** 259, 274, **277,** 278; **cothurnatus** 260, **261,** 264, 265, 268, 269, 270, 271; cothurnatus ssp. **aestivalis 261,** 263, 265; cothurnatus ssp. **hiemalis** 261, **263,** 264, 265; *cyanescens 235, 278; decipiens 254;* **flavidus 260,** 269; **flavoluteus 260; flavus 260;** granulatus 40, 41, 43, 44, 250, 260, 261, 267, **272,** 273; granulatus ssp. **leptopus 42,** 43, 44, 45, 261, 267, 272; granulatus ssp. **Snellii 40,** 41, 42, 45, 261, 267, 270, 272; granulatus ssp. typicus 41, 42, 44, 261, 272; Grevillei 259; hirtellus 98, 259, 268, 273, **274,** 277; hirtellus ssp. **cheimonophilus 274,** 276; hirtellus ssp. **thermophilus** 274, **275;** hirtellus ssp. typicus 277; hirtellus var. mutans 274, **277;** *hygrophanus 279; intermedius 246; jamaicensis 240, 279; lanatus 296;* luteus 41, 258, 260, 265, 266, 268, 269, **270,** 271, 273, 275; *Maxoni 279;* **piperatus 46,** 278; piperatus var. **amarellus 46,** 278, 300; **placidus 42,** 43, 45, 250, 260, **271;** placidus fa. *americana 43;* placidus fa. *Pini cembrae* 43; placidus fa. *Pini halpensis 43;* placidus fa. *Pini strobi 43;* **punctatipes** 257, **277; punctipes** 259, 262, 263, 270, 273, **277; rubinellus 47,** 278; **sibiricus 260;** *subalbellus 232, 279;* subaureus 260; subluteus 260, 264, 265, **269,** 270, 271; **tridentinus 260;** variegatus 278
Surirella 205–206, 213, 214; Amphioxys 206; angusta 205; biseriata 205; gracilis 205; guatemalensis 205; *intermedia 204;* Moelleriana 205, 206; *Palmeri 206;* splendida 205, 206; tenera 205, 206; tenera var. nervosa 206; tenera var. Palmeri 206

Synedra 153–155, 160; *acicularis 204;* acus 153; acus var. delicatissima 153; *danica 155; debilis 204; delicatissima 153; familiaris 154; lunaris 159;* lunaris var. *capitata 159;* minuscula 153, 154; *oxyrhynchus 155; palea 204; Ramesii 155;* rumpens 153, 154; rumpens var. familiaris 154; rumpens var. scotica 154; ulna 153, 154, 210; ulna var. danica 155, 208, 211, 212; ulna var. oxyrhynchus 155; ulna var. Ramesii 155

Tabellaria 148–149, 213; fenestrata 148, 208, 209, 210, 211; flocculosa 149, 207, 208, 209, 210, 211, 212
Tabellariae subgen. 187, 191
Taphrina deformans 345–383; epiphylla 349, 353; Klebahnii 349, 353
Tapinella 539; panuoides 540, *541*
Tapinia 539, 540; *lamellosa 541; panuoides* 540, *541*
Tayloria magellanica var. **gigantea 312**
Telimena *domingensis 467*, 468; sp. 468
Thamnocephalis 324
Tibiella 214; punctata 213
Tomentella 39
Tortula pseudorobusta 310; rivularis 310; robusta 310; robusta var. **laxa 310**
Torula histolytica 347; rubefaciens 371
Torulopsis neoformans 347, 375; pulcherrima 345–383
Trabutia conica 460; **Danthoniae 460**
Tremella *nidus-avis 481;* sp. 495
Tricholomataceae 527, 548, 562
Tristes sect. 107, **115**
Truncocolumella 255
Tryblionella *gracilis 205*
Tubiporus *porphyrosporus 115*
Tuomeya 68
Tylopilus 105, 106, 121, 122, 225, 228, 230, 240; alboater 122; conicus 99; felleus 121; *gracilis 121;* plumbeoviolaceus 258; Rhoadsiae 240; *subflavidus 120;* tabacinus 240
Typhula 436

Uloporus 243; lividus 243, *249;* lividus var. *rubescens 249*

Vanheurckia 170–172, 212, 213; rhomboides 170, 207, 212; rhomboides var. amphipleuroides 170, 211, 212; rhomboides var. crassinervia 171, 207, 208, 209, 212; rhomboides var. crassinervia fa. **capitata 171,** 208, 212; vulgaris 171
Versipellis 258
Viscipellis 258; lutea 258; variegata 258
Viscogomphus sect. 528, 529
Volvoboletus 562

Wormskioldia 24

Xanthoconium 223, 225, 228, 230; stramineum 234, 240
Xerocomoideae 227, 251, **279**
Xerocomopsis 284
Xerocomus 128, 224, 225, 227, 230, 258, 279, **284**–300, 538; sect. **Brasiliensis** 287, **298;** sect. Parasitici 287, 297; sect. **Pseudoboleti** 287, **299;** sect. **Pseudophyllopori 287**, 296; sect. Subtomentosi 287, **297;** *amarellus 300;* armeniacus 300; *auriporus 300;* badius 258, 287, 299; Boudieri 299; **brasiliensis** 258, 297, **298;** chrysenteron 297; chrysenteron var. versicolor 300; **coniferarum** 286, 287, 288, **297;** *flaviporus 300; gentilis 300; griseus 300;* **hemixanthus** 288, **292,** 296; **Housei** 288, **296; hypoxanthus** 288, **289,** 293; **illudens** 281, 285, 286, 287, 289, 290, **293,** 295, 296; illudens ssp. typicus 289, **294;** illudens ssp. **xanthomycelinus** 289, **294,** 295; *impolitus* 285, *300;* **Junghuhnii 297; lanatus** 288, **296;** lignicola 299; **Linderi** 288, **296;** *mirabilis 129, 300;* parasiticus 224, 297, 298; pruinatus 300; **pseudoboletinus** 288, **290;** *pulverulentus 300;* radicans 300; *rubellus 300;* spadiceus 286, 297; **squarrosoides** 250, 255, 257, 288, 293, **295,** 296; subilludens 100; subtomentosus 281, 285, 286, 297; subtomentosus var. *Leguei 297;* subtomentosus ssp. spadiceus 297; *sulfureus 300;* tumidus 300; versicolor 300; Zelleri 297; *sp. 300*

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